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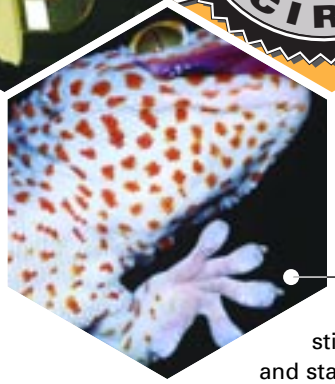
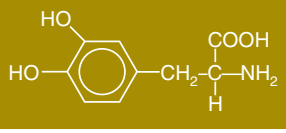


WHAT'S IN THE LOGO?

L-3,4-DIHYDROXYPHENYLALANINE (DOPA) is an amino acid that acts as the secret glue of mussels. They use the molecule's water-resistant and powerful adhesive qualities to stay anchored. DOPA sticks to almost any surface, even Teflon, and polymers modeled after it are of great interest in adhesion research. See Sticky Science, Page 30



DEPARTMENTS

Chemistry

Chemistry, published three times a year for American Chemical Society members, focuses on the science and people in chemistry.

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Chemistry is a newspaper published for ACS members interested in learning more about the chemical sciences and ACS.

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EDITORIAL

As a rookie newspaper science writer in 1969, my first big assignment was covering the 158th national meeting of the American Chemical Society in New York City. The owner of my newspaper group, the late Paul Block, Jr., was a Ph.D. organic chemist, chair of the local ACS Section, doing part-time research synthesizing analogs of thyroid hormones and publishing regularly in good journals.

What a great chance to score brownie points with the boss and showcase my chemistry expertise! I'd get some great stories, do a lot of networking, and make contacts. And hey…well…ok….there also was the chance to network with that social worker in New Rochelle, a quick train ride from NYC, who soon would become *me Señora*.

ACS was back in New York, of course, for its 226th national meeting last September. During those intervening years, something quite surprising happened. I got older. Now I'm among a sizeable group of ACS members eying eventual retirement. At age 57, it won't be soon. I hope. Cross my fingers. Knock on wood. And like many of them, it probably will be retirement from one career and the start of another.

With life expectancy hovering around 80, and the 85-plus age group the single fastest growing segment of the population, that second career may rival the first in length. And it can be just as rich in terms of achievement—and richer in breadth of opportunities opening in the future.

Reduced career and family demands, for instance, will give some ACS members their first real opportunities to serve in the many volunteer positions so important to ACS activities. This edition of *Chemistry* showcases the all-around benefits of serving in those positions, for both younger and older members. It focuses on Eli M. Pearce's (ACS '49) idea for a "Silver Circle" of senior members. The past ACS president envisions a program that would encourage retired members to stay involved in chemistry and ACS activities.

Rachel Smolkin gives a good overview in her feature article on the Silver Circle, and Don Frederick follows up with a profile of Val Kuck (ACS '64), who has become a role model for volunteerism within the ACS. ACS just originated a new national award for volunteer service, and Kuck will be the inaugural recipient at the 227th national meeting in Anaheim. She amazes me, having found time to volunteer during a productive career, despite the demands of a family. Now Val is continuing, and showing others how it's done.

In another feature in this edition of *Chemistry*, Joan Stephenson explores the mysterious link between two endeavors that seem light-years apart: chemistry and music. A seemingly unusual number of chemists and other scientists have musical talent. Stephenson was the perfect author, being a Ph.D. in biology and a flutist with two brothers who are scientists and musicians.

Read a few words of Eli Kintisch's feature, and I guarantee, you'll get stuck—on his insights into the search for the secret of stick. The fascinating story focuses on adhesives and glues. One surprise to me was the enduring nature of ancient glues, with those made from fish and animal hides still in use.

Scott Baltic takes readers on a news-you-can-use stroll through the Web in his Internet column in this edition. Count on it, winter weather will get you one way or another. Baltic reviews one suite of weather forecast web sites and another for monitoring airport conditions and flight delays.

And if you want to get your name in the newspaper, too, heed the advice on publicizing research results from *Chemistry*'s resident know-it-all, the Lab Rat.

Michael Woods (ACS '96)
Editor, *Chemistry*
chemistry@acs.org

Michael Woods (ACS '95), a winner of the ACS Grady-Stack Award for Interpreting Chemistry to the Public, is a newspaper science writer and author in Washington, DC.

One cool gas

CALL THIS RESEARCH a real gas. One very, very cool gas.

Scientists at the Massachusetts Institute of Technology have cooled a sodium gas to the lowest temperature ever recorded—only a half-billionth of a degree C above absolute zero. At absolute zero (roughly –273.15 °C or –459.67 °F) atomic motion stops because cooling has drained all energy from the system.

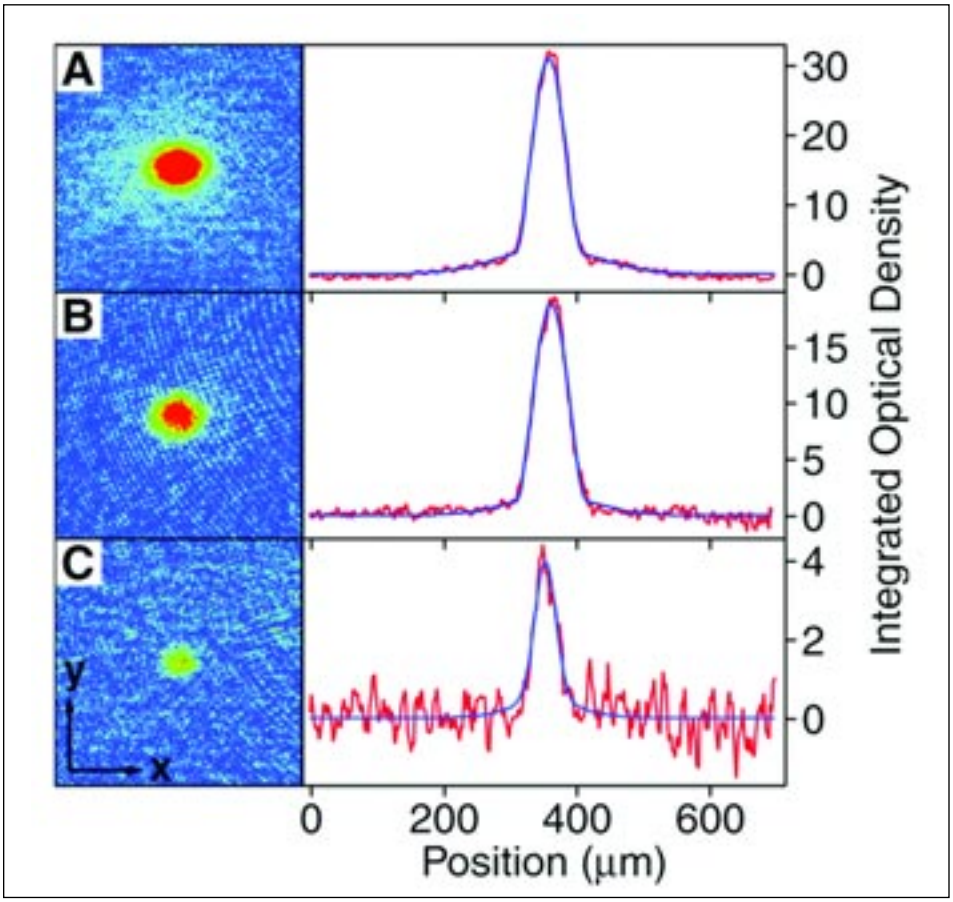
This is the first time a gas has been cooled below 1 nanokelvin (one-billionth of a kelvin).

"To go below one nanokelvin is a little like running a mile under four minutes for the first time," said Nobel laureate Wolfgang Ketterle, coleader of the team.

"Ultra-low-temperature gases could lead to vast improvements in precision measurements by allowing better atomic clocks and sensors for gravity and rotation," said David E. Pritchard, also a team coleader.

The researchers hope to observe and study new phenomena that occur at such low temperatures, when gases form a weird state of matter termed a "quantum fluid." In 1995, Ketterle worked with Eric Cornell and Carl Wieman at the University of Colorado–Boulder to cool atomic gases below one microkelvin (one-millionth of a degree above absolute zero). In doing so, they discovered a new state of matter, the Bose-Einstein condensate, and won the 2001 Nobel Prize in Physics.

Since then, other researchers have routinely cooled gases into the nanokelvin range. Three nanokelvin was the old record low. The MIT group reached a temperature of 500 picokelvin—6 times lower. ⬢

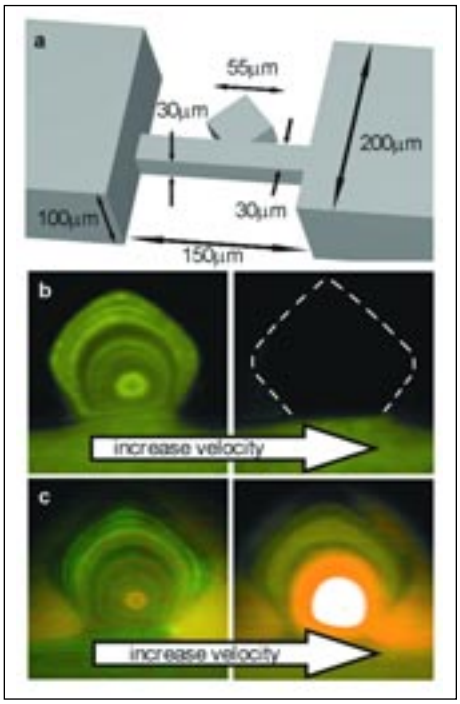


SCIENCE

PARTIALLY CONDENSED atomic vapors confined in the gravito-magnetic trap with (A) 28,000; (B) 16,000; and (C) 2,500 atoms. The one-dimensional cross sections (red) were obtained by integrating the two-dimensional absorption images of the trapped clouds along the y axis.

Whirlpool from hell

CARE TO RELAX those aching bones in the hotel whirlpool after that long trip, dear? Not this particular whirlpool, thank you very much.



DANIEL CHIU

MICROCHANNEL (a) was used to create the microvortex (b and c). Dimensions are given in microns. Fluorescent beads in the chamber were spun out as the flow velocity increased.

Researchers studying small-scale chemical processes have discovered that fluid circulating in a microscopic whirlpool can reach radial accelerations of 1 million Gs. Those forces are a million times greater than the human body feels from the ordinary pull of gravity.

A jetfighter pilot's body, in contrast, might be squished by a force of 10–12 Gs, if he or she flew tight circular patterns at very high speeds.

"From a physical perspective, it's not so surprising," said Daniel Chiu (ACS '99), whose chemistry lab at the University of Washington discovered the small whirlpools packing stunningly strong forces. "The number of Gs goes up with an increase in velocity and the reduction in radius."

Chiu and co-workers were surprised, however, at how acceleration soared when the radius of the vortex (the tight circular pattern in which molecules were flying) was reduced to minute scales.

They stumbled on the discovery while doing research on microfluidics, which involved creating vortices in a chamber about one-third the diameter of a human hair. It held less than a millionth of a liter of water. That research may have important future applications, for instance, in microfluidic analysis systems for minute samples of chemical and biological material.

Chiu noted that accelerations approaching and possibly exceeding 1 million Gs now can only be achieved in big commercial and government centrifuges. ⬢

King Hezekiah's tunnel

WHO REALLY BUILT the Siloam Tunnel, the biblical engineering marvel that brought fresh water into the ancient city of Jerusalem and remains in use today?

Modern radiometric dating technology has ended a squabble among biblical scholars, proving that the tunnel was excavated by the Judean King Hezekiah around 700 BC.

"This is the first time that a structure mentioned in the Bible (2 Kings 20:20 and 2 Chronicles 32:3,4) has been radiometrically dated," said Amos Frumkin, of Hebrew University in Jerusalem. He did the work with associates from the Israel Geological Survey and Reading University in England.

Frumkin noted that dating biblical structures is very difficult because of poor preservation of datable materials, restricted scientific access to well-identified sites, and other problems. Scholars thus assumed that King Hezekiah ordered the tunnel's construction based mainly on the biblical texts. Some, however, argued that it was built long after Hezekiah's reign.

Radiometric dating is based on the decay of radioactive elements which serve as physical clocks that scientists can use to estimate the age of materials. Frumkin´s group used carbon-14 to date organic material in plaster lining the Siloam Tunnel and uranium–thorium for dating stalactites that grew in the tunnel since its construction.

The half-kilometer-long tunnel was an engineering innovation, constructed without digging intermediate shafts. For thousands of years, tunnels had been dug by excavating vertical shafts from the surface, and then digging to connect the shafts' bottoms. ⬢

Life at 121

AN EYEBROW WOULD RAISE at news of an organism living to 121 years, a mark even people haven't reached. But living at 121 degrees Celsius—250 degrees Fahrenheit—under enormous pressure? That's stretching the imagination.

Confident that no life at 121 is possible, the medical community, for instance, relies on sterilization at 121 °C in pressurized autoclaves as the standard procedure that guarantees death to all microorganisms and heat-resistant spores.

Derek Lovley (ACS '94) and Kazem Kashefi, University of Massachusetts–Amherst, have identified a new microbe that thrives at such temperatures. Dubbed strain 121, it leads the hottest existence known to science.

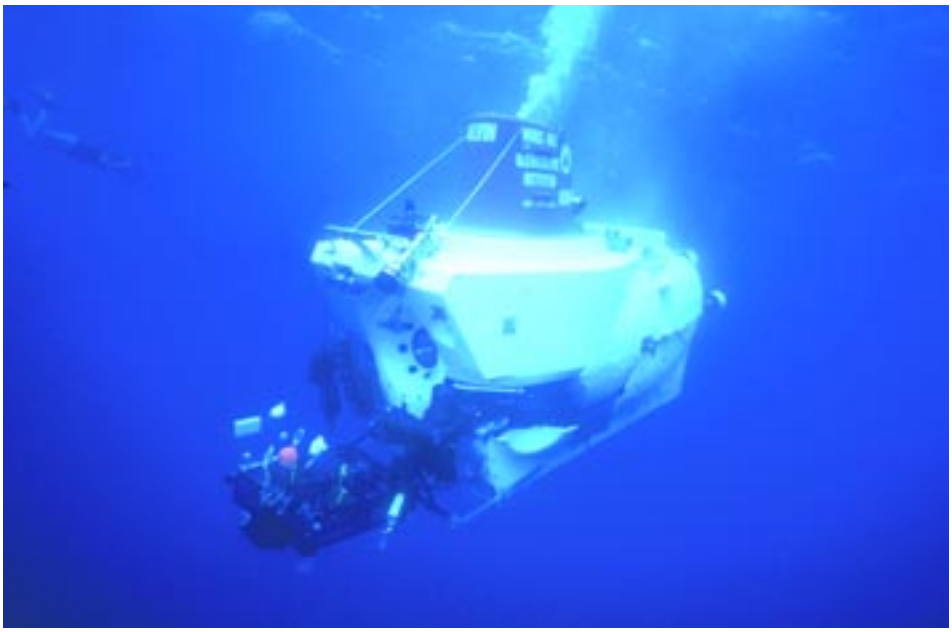
The upper known temperature limit for life on Earth had been 113 °C, or 235 °F, a record held by a microbe called *Pyrolobus fumarii*. Strain 121 and *P. fumarii* are hyperthermophiles—organisms that love extreme heat.

They populate the surreal realm of hydrothermal vents on the deep-sea floor. Heated by Earth's magma, water there spouts forth through leaks in the ocean floor. Immense pressure keeps the water from turning to steam, even though it can emerge at 400 °C (750 °F).

Strain 121's habitat is also toxic, laced with sulfur iron compounds.

"The upper temperature limit for life is a key parameter for delimiting when and where life might have evolved on a hot, early Earth; the depth to which life exists in the Earth's subsurface; and the potential for life in hot, extraterrestrial environments," Lovley and Kashefi pointed out.

Such heat-loving microbes, and their hardy enzymes, may find applications in industrial processes, remediation of toxic contaminants, and other fields. ⬢



WOODS HOLE OCEANOGRAPHIC INSTITUTION

SUBMERSIBLES LIKE Alvin enable scientists to study strange life forms that flourish in extreme environments on the seafloor.

Fast Internet connection

TALK ABOUT AN UNDERSTATEMENT.

People gasped last February when scientists at the Los Alamos National Laboratory in New Mexico announced a new record for transmitting data over the Internet. They transmitted data from one computer to another at 2.38 billion bits per second (bps)—2.38 gigabits per second—setting a new land-speed record for the Internet.

A typical dial-up telephone modem, in contrast, transmits at less than 56,000 bps. A bit, or binary digit, is the smallest unit of data storage in a computer. Eight bits make up one byte, and are enough to represent one letter, number, or other character.

"What's remarkable about this achievement is that no special equipment is needed other than commodity Intel Ethernet cards that we fine-tuned," said Wu-chun Feng, who headed the team.

At those speeds, it would take less than 20 seconds to transmit a full-length DVD movie, and about 14 hours to send the entire contents of the Library of Congress from one computer to another.

Then, in October, another team at the European Organization for Nuclear Research (CERN) in Geneva doubled that by sending 1.1 terabytes of data at 5.44 gigabits a second to a lab at the California Institute of Technology. That's 20,000 times faster than a typical home broadband connection, equivalent to sending a 60-minute CD-ROM in 1 second.

Feng predicted that within a couple years, consumers would be able to afford to buy the hardware, wiring infrastructure, and software to approach those sizzling speeds. ⬢

"Matchbox" atomic clock

TIME KEPT BY THE BEST wristwatches and wall clocks is not accurate enough for high-tech communication and precision navigation systems. Ground-to-outer-space communication, for instance, and navigation of aircraft, ships, and missiles, require ultra-precise atomic clocks.

The Office of Naval Research (ONR) has unveiled the next-generation atomic clock, which is small enough to strap on your wrist. The Ultra-Miniature Rubidium (Rb) Atomic Clock is about the size and weight of a small matchbox and needs barely one watt of power. A typical commercial cesium-beam atomic clock is about the size of a large backpack and consumes up to 50 watts.

ONR's John Kim, who oversaw the clock's development by Kernco, Inc. (Danvers, MA), terms it "a tactical grade atomic clock." The device, which can run almost 10,000 years without losing 1 second, will find its first uses in aerospace and other applications where size and weight are important.

The clock is entirely optical in design, which Kim described as a key breakthrough that permitted miniaturization. It uses an extremely compact Vertical Cavity Surface Emitting Laser (VCSEL), technology originally developed for fiber-optic communications.

"Matchbox" definitely is not the last word in atomic clock size. Kernco already is working on a device that will be four times smaller. ⬢

ONR

JOHN KIM and Mini Atomic Clock

Winter Weather on the Net

Ask three meteorologists whether that winter storm will be a hit or miss, and you'll discover that opinions often differ. That's why it pays to pool information in several different forecasts, and then add a reality check by looking out the window. Bookmark this suite of weather sites as you face winter's onslaught.

Interactive Weather Information Network

http://iwin.nws.noaa.gov/

PICK JUST ABOUT ANY CITY, and this National Weather Service site provides chapter and verse on current conditions, including recent high and low temperatures, precipitation, and a 24-hour recap of hourly temperature, dew point, pressure, wind, and precipitation.

National Weather Service

www.nws.noaa.gov

STOP HERE FOR A FORECAST without weather-geek minutiae. Though people are justifiably skeptical about a "Detailed 7-Day Forecast," the predictions often are reliable. The site has cool radar and satellite images, as well as specialized forecasts and maps.

Weather.com

www.weather.com

ONLINE COUNTERPART to cable TV's The Weather Channel, it offers national and regional forecasts, with near-real-time satellite images and movies. You can also join an e-mail list for periodic air-quality forecasts and other information.

AccuWeather.com

www.accuweather.com

THE FOLKS AT ACCUWEATHER seem to take particular pride in their graphics and their hour-by-hour localized forecasts. They can be a boon for travelers hoping to catch a plane as storms threaten an area.

Winter-Weather Travel Glitches

Count on it. Snow or ice will jumble those travel plans at least once, as you try to get there and back. Check flight delays and cancellations with your own airline before venturing to the airport, and flight and airport status with this group of sites.

FlightArrivals.com

www.flightarrivals.com

PLUG IN AN AIRLINE, a flight number, and a date, and get the flight's status, as well as the weather at both departure and destination airports. Or easily check two hours' worth of flights at the airport of your choice. Check distance and time from arrival for flights still in the air, plus current weather and general delays at more than 70 major U.S. airports.

FlyteComm

www.flytecomm.com

FLYTECOMM PROVIDES mostly business-oriented flight-tracking services, but it also lets anyone track individual flights quickly and easily. You'll get departure and arrival cities and times, current altitude and speed, and aircraft type.

FAA Air Traffic Control System Command Center

www.fly.faa.gov/flyfaa/usmap.jsp

THE FAA'S REAL-TIME Airport Status page provides a U.S. map with major airports color-coded for their delay status or closures. Check the more detailed regional maps for smaller airports. The maps automatically update while you're online.

Time Online

"Does anybody know what time it is?" Lots of folks do—to the fraction of a second—and these sites will happily tell you.

The Official U.S. Time

www.time.gov

AN EASY ADDRESS to remember plus an easy-to-use interface. Just click on your time zone and get your time, plus or minus 0.3 second. Check the map showing current global zones of daylight and nighttime. All federal programs should be this simple and effective.

Time Ticker

www.timeticker.com

A FANCIER INTERFACE, including sound effects—as expected from a commercial site. Click on a country, or simply drag the cursor across a world map for a different time zone.

U.S. Naval Observatory

http://tycho.usno.navy.mil/

"THE OFFICIAL SOURCE OF TIME for the Department of Defense and the Global Positioning System (GPS), and a Standard of Time for the United States." Need we say more?

NIST Time and Frequency Division

www.boulder.nist.gov/timefreq/

PART OF THE NATIONAL INSTITUTE of Standards and Technology, the Division's services include Internet Time Service for quickly synchronizing your computer's system clock.

"Free Software"

It's an Internet conundrum: How much do you have to pay to get something for "free?" Free software sites abound in the cyberworld and some really do offer free programs. Consider the following:

Completely Free Software

www.completelyfreesoftware.com/index_all.html

THIS AUSTRALIAN-BASED SITE offers members free utilities, games, graphics, and Internet applications. The stuff is free once you pay a $5-a-month membership fee. All software here is "hand-picked, tested, reviewed and rated."

FreewareArena.com

www.freewarearena.com

WHEN THESE FOLKS say "freeware," they mean it. There's no shortage of choices, either, with downloads ranging from online-auction tools and font utilities to multimedia and programming software. No membership fee.

Nonags

www.nonags.com

NONAGS SPLITS THE DIFFERENCE between a membership and a non-membership site by offering both. Visit the free side for a wide range of free downloads, or pay $22 a year for access to NonagsPLUS (no ads, an MP3 section, and other value-added extras).

Jumbo!

www.jumbo.com

FREE DOWNLOADS INCLUDE software to label and organize digital photos, encryption programs, and a program to safely store multiple passwords. Unlike the previous three sites, Jumbo offers software for Linux and Macintosh computers, not just Windows.

NSF Chemistry

NSF Division of Chemistry

www.nsf.gov/home/mps

THE NSF DIVISION OF CHEMISTRY (CHE), part of the National Science Foundation's Directorate for Mathematical & Physical Sciences (MPS), strives "to promote the

health of academic chemistry and to enable research and education in chemistry at the highest possible professional, technical, and creative levels." In actual practice, that means providing about 20 percent of the federal research funding for academic chemistry—to the tune of about $150 million in 2001. This site is the gateway, with information about grants, fellowships, and other funding sources. One of the newest research efforts, sponsored by the MPS as a whole, is Approaches to Combat Terrorism. In conjunction with the intelligence community, the program funds basic research "with the potential to contribute to national security."

PBS Science

Science & Technology–PBS

www.pbs.org/science/

Put "Neighborhood" in the same sentence as PBS, and you'll likely think of the late, great Mr. Rogers. No cardigans here, but under categories like Archaeology & Anthropology, Earth & Space, Inventions and Science Mysteries, there's plenty of browsing and interactivity, with much of the material taken from the respected Nova and Frontline series. Under Inventions, for instance, take a virtual tour of the Great Pyramid of Khufu (Cheops) through the passages, galleries, and burial chambers of this legendary monument. "The Nobel: Visions of our Century" offers a timeline of Nobel controversies and scandals, half a dozen lesson plans for grades 8–12 (with downloadable PDFs), and a Flash-powered game, "Name That Nobel."

Quick Hits

Book-A-Minute

www.rinkworks.com/bookaminute

Do Cliffs Notes take too much effort? Think *Reader's Digest* stories are too long? Need something ultra-condensed? How about *Lord of the Flies* in 50 words? *Hamlet* in a dozen? *War and Peace* in two sentences? Good for the terminally attention-span-deprived, or just for a quick laugh.

Panopticon Lavoisier

http://moro.imss.fi.it/lavoisier/

Antoine Lavoisier's gifts to chemistry are showcased in this "virtual museum," which includes a catalog of the famed chemist's manuscripts, digital editions of his collected works, and a 500-item catalog of his lab apparatus.

Intellectual Property at the National Academies

ip.nationalacademies.org

Genetic engineering technology, electronic publishing, and other innovations are opening new issues in intellectual property rights. Here are key resources, including the 2003 book *Patents in the Knowledge-Based Economy* and proceedings of a recent symposium on electronic publishing in the sciences.

Find A Grave

www.findagrave.com

Here's where you can find the burial places of 40,000 personages, from Murder Inc. member Frank Abbundando (Saint John's Cemetery, Queens, NY) to one-of-a-kind musician Frank Zappa (Westwood Memorial Park, Los Angeles).

American Chemical Society's Chemical Abstracts Service

www.cas.org

"The most complete and effective digital information environment for scientific research and discovery," CAS offers 22 million documents from 40,000 scientific journals (some cases going back to 1907) plus the CAS Registry, patents, conference proceedings, and more.

Scott Baltic is a Chicago-based writer and editor who has covered topics ranging from the National Electrical Code and peer review to commercial real estate. He is the editor of Homeland Protection Professional, *a trade magazine.*

International Fellowship Programs

Modern chemistry knows no national boundaries. That fact is the driving force behind two prestigious international fellowship programs that offer recent or prospective Ph.D. recipients excellent opportunities to work and gain experience abroad.

Looking for adventure, a chance at career advancement, and a decent salary? Eager to meet new colleagues in foreign lands? If you are a U.S. citizen and a recent or soon-to-be Ph.D. recipient, particularly in chemistry, then organizations such as the Human Frontier Sciences Organization (HFSO) and National Science Foundation (NSF) want YOU to apply for one of several prestigious international fellowship programs.

As readers of this column know, I'm a firm believer in taking an opportunity early in your career to work overseas. I did. And that experience proved to be a springboard to an exciting and satisfying career that has taken me much further professionally than I ever expected. Now you, too, can have an opportunity to work in a premier laboratory overseas, thanks to a host of programs that aim to increase the meager number of U.S. students who take an opportunity to study overseas. Doing so could give you an advantage when it comes time to look for a job, particularly because so many U.S. students seem reticent to journey abroad for their postdoctorates.

"For any number of reasons, there seem to be fewer American students today who are willing to come and study overseas," said Martin Reddington of HFSO. Based in Strasbourg, France, the organization encourages interdisciplinary research among teams of scientists from different countries. As director of scientific affairs and communications, Reddington keeps track of who is applying for grants, and knows that over the past decade the percentage of young scientists who receive funding from HFSO has dropped from 75% to 56%. "It's a shame, because the students who do participate make the best of the opportunities presented to them." An added shame is that the North Atlantic Treaty Organization, or NATO, has stopped awarding fellowships to Americans who wish to study in Europe, restricting the program to Europeans who wish to do their postdoctoral studies in the United States.

HSFO & NSF: Filling the gap

Not to worry, though, as other organizations have stepped into the gap. For chemistry students wishing to broaden their research horizons, HFSO presents an ideal situation. "We're especially interested in having students in chemistry and other physical sciences apply to the program to get training in the life sciences," said Reddington. He noted that HFSO makes a point of funding outstanding Ph.D. students who come from other than the top research universities. Prospective fellows are expected to have a specific host scientist and project in mind when applying for the three-year, $45,000 per year fellowship. It includes allowances for travel and research expenses. Guidelines and applications are available online at www.hfsp.org/how/appl_forms_LTF.htm.

NSF offers two fellowship programs for those wishing to study overseas. The International Research Fellowship Program is open to any American citizen or permanent resident in any field of science or engineering. The Distinguished International Postdoctoral Research Fellows program is a relatively new attempt to specifically entice American physical science students into taking that leap overseas.

The latter program, run by NSF's Directorate for Mathematical and Physical Sciences (MPS), is designed not only to provide international study opportunities, but to serve as an honorific that would boost any young professional's career. "What we're trying to achieve is to encourage freshly minted Ph.D.s in the MPS disciplines to establish international connections early in their careers," said Henry Blount (ACS '67), head of the Office of Multidisciplinary Activities in the MPS directorate. "This is critically important in chemistry, particularly, because chemistry hasn't been as international in scope as physics or astronomy. Yet many of the most critical developments in chemistry—and in allied disciplines such as materials research—are occurring overseas as much as they are here in the United States."

To encourage the absolute best Ph.D. students to apply, the fellowship comes with a stipend of up to $100,000 a year. That's intended, in part, to encourage fellows to travel extensively among sites overseas, as well as to the United States, in order to form and maintain what Blount calls "dynamic professional contacts." NSF is aware that students who go abroad often feel cut off from their professional colleagues back in the United States. Some are concerned that the isolation may hurt their chances of returning to America and securing a good position. "We've structured this program to eliminate that obstacle," explained Blount.

To be eligible for either fellowship, an applicant must be a U.S. citizen or permanent resident, and must have earned a doctoral degree within three years of application or expect to receive a doctorate by the date of the award. In addition, prospective fellows must have a project and mentor in mind in an eligible host country. Currently, both fellowships provide for up to two years of support. Information is available online about the International Research Fellowship Program at http://www.nsf.gov/pubs/2002/nsf02149/nsf02149.htm and about the Distinguished International Postdoctoral Research Fellows program at http://www.nsf.gov/pubs/2001/nsf01154/nsf01154.html. Applications for both programs are due in the fall.

"A completely fantastic experience"

For NSF fellow Chris Clark, the Distinguished International Postdoctoral Research Fellows program has presented an outstanding opportunity to advance both his training and his career as a polymer chemist.

"This is a completely fantastic experience," said Clark, who was halfway through his two year stint at the Max Planck Institute for Polymer Research in Mainz, Germany, when we spoke about his experience. "For someone interested in polymer chemistry, this is the best place in the world. The expertise, the equipment, everything is top-notch, and the learning experience is going to put me in [an] excellent position for landing a good job when my fellowship is over."

Clark doesn't speak German, and he said one of the big surprises for him was that everyone involved in science in Germany speaks English. "It's such an international environment, particularly here at the Max Planck, that English is just the standard here."

That same international diversity is also one of the big plusses of his experience so far. Clark explains, "I'm going to have a huge advantage over my fellow students who stay in the U.S. because I'm really seeing the future of chemistry, and it's not going to be an exclusively American future. Here, I'm making great contacts that I certainly plan to keep up throughout my career." He added that the only negative apparent so far is that he's getting spoiled having contact with an internationally diverse group of colleagues. "The challenge is going to be figuring out how to work overseas on a regular, recurring basis once I'm settled back into the U.S.," he said of his high-class problem.

That's the kind of attitude that Susan Parris, program manager for international fellowships at NSF, loves to hear. "We believe strongly that it's going to benefit the United States if we can give more of our researchers a global vision at the earliest stages of their careers," she explained.

Science these days knows no national boundaries. Neither should you, and with programs like these, there are few excuses not to grasp those opportunities overseas. ⬢

Joe Alper (ACS '97) is a science writer in Louisville, Colorado, whose honors include the ACS Grady-Stack Award for Interpreting Chemistry to the Public. Chemistry*'s regular commentator on the overseas scene, Joe draws on his personal experience living and working abroad.*

Bioinformatics

Despite the name, this hot field is populated by many different kinds of chemists. More career opportunities will open as science confronts the problem of interpreting and applying gigabytes of genome data from humans and dozens of other organisms.

In 2000, scientists sprinted across the finish line of one of the 20th Century's great research events: sequencing the human genome, the complete set of genes that makes a person.

While excitement surrounding that feat has faded, savvy researchers are ecstatic about the bright opportunities awaiting in the further analysis of those 35,000 genes and 3 billion base pairs. And that's just for the human genome. Genome sequences for dozens of other organisms—ranging from disease-causing microbes to food crops to domestic animals—are pouring out of the gene machines.

Better get ready for the next race.

Whether you've just snared that first job, or are considering a mid-career shift, few fields offer brighter career opportunities than bioinformatics.

Don't let the "bio" part scare you away. Bioinformatics is wide open to chemists with strong computational skills. Bioinformaticians use quantitative methods to collect, analyze, and store the raw data of the genome and to answer biological questions.

Getting those answers and applying the results, however, demands the skills and creativity of chemists of many descriptions. Among them: analytical chemists, biochemists, synthetic organic chemists, physical chemists, protein chemists, combinatorial chemists, and medicinal chemists.

"When you're working at the level of DNA, it all comes down to chemistry in the end," said Glen A. Evans, CEO of Egea Biosciences, Inc., a company he founded in 2000.

Evans represents bioinformatics' past and future. As a researcher at the University of Texas Southwestern Medical Center in Dallas, he led one of the teams contributing to the human genome sequence project. But when sequencing was completed, bioinformatics offered a way to make the data useful, he said. Researchers at Egea use software to design new protein structures, then create them through proprietary technology by writing in the genome code and synthesizing the necessary DNA strands.

Evans said that the ideal bioinformatics researcher at a place like Egea would have a good grounding in biological theory and training in computer science. He went on to admit that it can be tricky to find someone with that mix of skills.

"There are the people who are developing new paradigms for computer programming, but it takes a lot of time to train them in a language they need to talk to biologists," he said. "The kind of problems they are trained to solve are very different. On the other hand, biologists know perfectly well what kinds of problems we are trying to solve, but they tend to approach computers as just a tool."

Strong chemistry emphasis

Chemists, particularly organic chemists, tend to have a quantitative background that suits them for working on bioinformatics problems, according to Evans. He noted that half of the scientists at Egea have chemistry degrees.

GLEN A. EVANS

"I generally believe that bioinformatics' quantitative approach is the future of training in biology and chemistry," said Shankar Subramaniam, professor of chemistry and biochemistry and director of University of California–San Diego's Bioinformatics and Computational Biology graduate program.

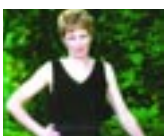
SHANKAR SUBRAMANIAM

Students should tackle databases and programming at the same time they learn the traditional chemistry and biology curriculum, said Subramaniam. He believes that such integrated training helps researchers develop the "modeling mentality" necessary in bioinformatics.

"Chemistry already contains a microcosm of the bioinformatics field, since it's interdisciplinary and quantitative to some extent," he said. And it may be easier for someone with mathematical skills to pick up the necessary biology than vice versa. "If you ask someone in the life sciences to start dealing with differential equations, they'll probably scream at you," Subramaniam joked.

The University of Pennsylvania is one school that offers both undergraduate and graduate degrees, as well as post-graduate work, in bioinformatics.

Penn developed undergraduate courses in computational biology when they discovered that most of the original applicants for Ph.D.s in bioinformatics were biologists with weak mathematical backgrounds, according to Susan Davidson, director of Penn's Center for Bioinformatics.



SUSAN DAVIDSON

Along with possessing good quantitative research skills, bioinformaticians may need to be familiar with a variety of programming languages, including C++, Perl, and JAVA. Knowledge of database programs like SQL and Oracle may also be important.

If you're the kind of researcher who enjoys building a better mousetrap to analyze your data, bioinformatics programming offers numerous opportunities to do so. For instance, Subramaniam designed his own Web-based resource called Biology Workbench, which helps researchers search protein sequence databases and related analysis tools.

Davidson feels that there is no substitute for hands-on experience with bioinformatics programming. At Penn, students are encouraged to develop their own algorithms and database tools and put them to work in academic or industry lab internships as a part of their degree programs.

Good pay

Bioinformatics researchers tend to be paid well for all their expertise. Salaries start in the $40,000–50,000 range with a bachelor's degree, and can climb to over $100,000 for a Ph.D. Researchers at the lower end of the range work mostly with the nuts and bolts of bioinformatics, designing the computer programs that collect, organize, and retrieve information. Researchers with advanced degrees, on the other hand, are more apt to be the ones analyzing the data to draw specific biological conclusions.

The average salary, $65,000, varies depending on geographic region. Salary hotspots include "biobelt" areas with a thriving biotechnology or genome sciences corporate sector, including California's Bay Area, Boston, and southern Maryland.

Bioinformatics is a growing career field, with 20,000 new jobs in the field expected by 2005, according to the National Science Foundation. Despite an economic downturn that has slowed overall growth in the biotechnology sector, the demand for bioinformaticians has steadily increased.

"The completion of the genome has stimulated bioinformatics and it's beginning to blossom, because we now have this immense resource of digital information that we need to understand," Evans said. "Our main bottlenecks now [occur because we need more] smart people to solve certain kinds of problems."

Most of the new jobs will be in industry, where bioinformatics' practical, problem-oriented focus is in high demand.

"The opportunity to solve problems is probably better in industry, mainly because of increased funding. Thirty years ago, nobody in industry was doing academic-quality research, but now I think it's the opposite," said Evans.

"What I tell people that we're recruiting is that if you want to write top-rated software, you'll work for Microsoft. If you want to create new molecules, you'll come to work for us, not in academics," he added.

"I still believe strongly that academia has a large share of people who can deliver this type of data analysis in a short amount of time," Subramaniam pointed out. He said that universities are quickly coming to the realization that bioinformatics is an important and legitimate field, and are hiring more faculty with computational biology experience.

Some established scientists, like Evans, saw the end of the genome race as the perfect chance to make a mid-career switch and start over again in a promising new industry. But others have ended up in bioinformatics through the natural evolution of their own research, particularly if they were already familiar with quantitative or programming methods.

"That's what happened to a lot of us," said Subramaniam. "None of us are 'bioinformaticians.' I think a lot of us just have a personality that is suited for analyzing and working with the gory details in our data." ⬢

Becky Ham has written a number of Chemistry*'s popular CareerView columns. She packs them with information valuable both to chemists with newly-conferred degrees and to more experienced scientists considering a mid-career shift. Ham writes from Washington, DC.*

BY RACHEL SMOLKIN

EXPERIENTIAL PROGRAMS IN CHEMISTRY

The ACS Experiential Programs in Chemistry office is connecting undergraduate students with internships, cooperative education programs, and other on-the-job work experiences that can jumpstart a career in chemistry.

Three years after completing an internship at Bristol-Myers Squibb, Gary Javadi (ACS '01) has an even greater appreciation of just how much it helped launch his career. Javadi, now a chemist at Merck, serves on a recruiting committee for bachelor's and master's level job candidates.

"Internships make candidates stand out amazingly," Javadi said. "That kind of experience on a resume looks good and isn't all that common."

GARY JAVADI (ACS '01) started his career at Bristol-Myers Squibb after completing a 12-week internship with the firm during the summer of his junior year in college.

Javadi completed a 12-week internship in drug discovery the summer after his junior year at the College of New Jersey in Ewing. He believes his previous work assisting a professor in organic synthesis research helped immensely in securing the competitive internship. He did so well that Bristol-Myers Squibb invited him back, and he continued his paid internship throughout his senior year.

"You get to learn a lot of advanced lab techniques, really get your hands dirty," Javadi said. "You are able to talk about chemistry with much more confidence."

The Experiential Programs in Chemistry (EPiC) office at the American Chemical Society offers a wealth of resources about experiential undergraduate programs such as internships, co-ops, study abroad, and service learning that supplement students' classroom experiences.

SA membership benefit

Many participants discover EPiC through participation in the ACS Student Affiliates Program, making it one of the often-overlooked benefits of SA membership.

The office does not place students but functions as an information clearinghouse. It produces the *Directory of Experience Opportunities*, which is published each September and lists internships, co-op programs, fellowships, and summer work opportunities. EPiC gives workshops at regional ACS meetings and also offers a resource packet on study- and work-abroad programs geared toward science students.

Emily Thompson, higher education assistant at ACS, said experiential programs help prepare students to enter the workforce after graduation and teach them to apply knowledge they've gained in the classroom.

She notes the 2002 ACS Starting Salary Survey found that college graduates with 12 to 36 months of work experience were offered $3,100 more per year than graduates with fewer than 12 months of experience and earned a median salary of $34,100 instead of $31,000. The difference is even more pronounced for graduates with more than 36 months of experience, whose median starting salaries were $9,000 higher than those of inexperienced peers.

At the Pennsylvania State University, science majors can participate in a co-op program that exposes them to multiple semesters of experiential work.

REBECCA COPELAND got valuable experience during a co-op with DuPont in LaPorte, TX, where she made Terathane, a stretchy polymer used in garments.

"Often the students know they like chemistry, but they don't know what area of chemistry or what particular application they want to take," said Susan Knell, director of the Science Cooperative Education Program and Science Study Abroad at the Eberly College of Science. "They come back and say, 'You know, I never thought there would be a use for physical chemistry, but amazingly enough, there is.' They can understand the importance of being able to communicate clearly and of the technical writing that they take here."

Among those students is chemistry major Rebecca Copeland, 21. In August 2003, Copeland completed an eight-month co-op with DuPont in LaPorte, TX, where she made Terathane, a stretchy polymer used in swimsuits, rubber, and even jeans. She ran instruments, learned problem-solving skills, and bolstered her command of analytical chemistry techniques.

Copeland also gained experience in giving directions to equipment operators older than she is. "You can't just come in here and be like, 'I know this, and this is how it goes,'" she said. She plans to pursue a Ph.D. in chemistry, and

PAUL GARABELLI studied in Ireland before graduating from Michigan's Albion College in May 2002 and enrolling in medical school.

the co-op experience showed her how much she enjoys the problem-solving aspects of analytical chemistry.

Studying abroad also can give students fresh perspective on their studies. Paul Garabelli, now at the Bowman Gray School of Medicine, studied in Ireland before graduating from Michigan's Albion College in May 2002. "It was so eye-opening, just the possibilities that are out there," Garabelli said of his time at University College Cork in southwest Ireland. "It's a good lesson in life just to go someplace brand new with practically nothing, meeting people, starting anew, discovering new towns."

The *Directory of Experience Opportunities* is available online at http://chemistry.org/education/epic. A limited number of 2004 directories will be printed and sold for $10 each. Thompson can be reached at epic@acs.org.

Rachel Smolkin, Chemistry*'s regular Student Affiliates columnist, is a freelance writer in Washington, DC, who counts education among her specialties. She is the author of the feature on the Silver Circle in this edition.*

VALERIE KUCK (ACS '64) has become the role model for the kind of volunteerism that ACS seeks to encourage among members, especially older chemists.

Val Kuck

The Silver Circle's Golden Member

Val Kuck may be the perfect role model for the kind of post-retirement volunteer service that ACS hopes to encourage with its "Silver Circle" concept. She served in an array of positions during a productive career, and continues on volunteerism's fast track today.

For years Valerie J. Kuck (ACS '64) has worked tirelessly so that women, children, and individuals launching new careers could share chemistry's abundant rewards.

Whether encouraging female students to consider careers in chemistry, introducing a child to the wonders of science, fine-tuning a CV, or mentoring a new employee, Kuck has always felt an obligation to open doors for the next generation of chemists and chemical engineers.

She certainly has done her bit for the American Chemical Society by immersing herself in countless society activities and committees. Additionally, during the same 34 years, Kuck held a full-time job at Lucent Technologies' Bell Laboratories. Retirement in 2001 didn't alter Kuck's commitment to volunteer work one bit. Indeed, it freed extra time for this pursuit, and Kuck has emerged as a role model for the kind of post-retirement involvement and volunteerism that ACS seeks to encourage in the years ahead. (See "Chemistry's Silver Circle," page 25.)

Inaugural volunteer service medalist

Recognizing her decades of extraordinary work, ACS will give Kuck its first Award for Volunteer Service at the spring national meeting in 2004.

"Getting recognition for all my activities in a first national award completely floored me," Kuck said. "It was humbling considering all the generous, wonderful people I've met through ACS who care about making a difference."

Nina I. McClelland (ACS '67), Chair, ACS Board of Directors, thinks the award is well deserved. As she pointed out, "Val Kuck has given freely and generously of her time, expertise, and experiences to our society. She truly exemplifies the criteria established for the Award for Volunteer Service for which she has most appropriately been elected by her colleagues and peers to be the first recipient."

Kuck, 63, regards retirement as the opportunity to enhance her involvement in the central science. "Just because you're retired doesn't mean you're dropping out of life," she philosophizes. "It's important to continue to support your discipline, learn new ideas, and read journals and publications such as *Chemical & Engineering News*. Knowing what's going on in your field should remain part of your life, not the part of a life you want to drop out of."

Shortly after retirement, Kuck became an adjunct professor at Seton Hall University in South Orange, NJ, and formed a group to study the status of women in chemistry and the physical sciences at colleges and universities.

Results of the study, slated for publication late in 2003, will show "the tremendous power the top 10 schools ranked in chemistry have in placing doctoral graduates on faculties around the country," Kuck said.

The report indicates that women aren't proportionately represented in the postdoctoral cohorts at these schools, and the general outlook doesn't seem encouraging.

"For some reason, women don't seem to be doing postdocs at the same level that men are," Kuck commented. "I have a gut feeling that women in industry are treated better than those in academe. One of the big problems in academe is that women aren't viewed as equal partners in the scientific community along with men and that goes into the issue of respect."

Encouraging women in chemistry

An ACS member since 1964, Kuck has long been interested in women's issues. In 1974, she cofounded the Metro Women's Chemist Group of ACS's North Jersey and New York Sections to support women chemists and help them reach their potential.

ACS crowned her efforts with the prestigious Award for Encouraging Women in the Chemical Sciences, sponsored by the Camille and Henry Dreyfus Foundation.

The award in 2000 especially recognized her initiative at Bell Labs, where she became known as "Mother Kuck," because her open door policy encouraged dozens of women interns to drop by and discuss everything from research projects to finding the right grad school and research adviser.

Reaching out even to young kids, chemistry's nurturing mom helped organize the North Jersey Section's National Chemistry Week activities for children. Still actively involved, she's always on the lookout for people willing to do hands-on chemistry for the thousands who show up.

She always seems to get a disproportionate number of women volunteers, which sometimes confuses young participants. Kuck recalls "the little lad who was having the time of his life and suddenly turned to me and wistfully asked, 'Can't boys be chemists?'"

Kuck thinks that National Chemistry Week is a great way for young people to get started in ACS activities. "If someone wants to do something, give back a little bit for all the care they've gotten along the way, it's a great way to start because it's not a long commitment."

Helping ACS is a growth opportunity, according to the veteran volunteer. "You learn a lot and meet wonderful people," she said. "There's the added advantage of taking on risks and responsibility, seeing how well you can cope, and you're not risking your regular job."

A volunteer's impact on ACS

More than just a willing worker, Kuck has blazed the trail for many ACS activities. She is credited with creating Sci-Mix, an evening poster session held at ACS national meetings, and with introducing cutting

edge symposia on hot research topics. The spectacular success of sessions on high-temperature superconductivity in 1987 and cold fusion in 1989 led to a change in ACS bylaws to accommodate symposia on late-breaking topics.

A symposium organized by Kuck and George S. Hammond inspired them to co-edit the book, *Fullerenes: Synthesis, Properties, and Chemistry of Large Carbon Clusters*, which was published by ACS in 1992.

Somehow, Kuck also found time to chair five of the society's national committees. Of all her ACS accomplishments, she's proudest of her Committee on Committees tenure. Kuck found it "extremely rewarding that we streamlined some things and worked with other committee chairs to help improve their groups and make them the best they could be."

Cheryl H. Brown, program manager for women and minorities in science at ACS, has worked enthusiastically with Kuck on various projects for more than 10 years. "She's a hard worker who understands the needs of the scientific community and always gets the job done," said Brown.

The energetic Kuck displayed the same can-do attitude at Bell Labs, where she published 34 papers and racked up 20 patents while providing the drive for a lot of team efforts.

During her formative years in Milwaukee, WI, Kuck's eagerness to help others was inspired by her parents. "My dad always used to talk about making things better," she recalled. "It was the kind of philosophy that I grew up with."

Her parents also encouraged their only child not to follow a traditional female career path during the somewhat conformist 1950s. So it didn't surprise them when she got honors in high school chemistry, majored in the subject at Saint Mary-of-the-Woods College in Indiana, and received her master's degree in chemistry from Purdue University in 1964.

A degree plus at Purdue

The young graduate got more than a degree from Purdue, because that's where she met her husband, Mark, a helpmate who has steadfastly backed her many endeavors through the years.

According to Kuck, whose two children are thriving, a supportive husband and healthy children were important accompaniments to her career. Son Justin, 26, works as a mechanical design engineer for an aerospace firm in California. Daughter Melissa, 29, is a resident in pediatrics at Children's Hospital in Philadelphia.

Dedicated to seeing that others get opportunities, Kuck serves as a career consultant for ACS, which sends her three or four resumes a month. She counsels the job seekers and fine-tunes their resumes. At least once a month, she holds a workshop on resume writing for people in her area and advises them how to respond to difficult questions during live interviews.

Kuck's resume reputation has spread far beyond the chemistry community and requests for help now also come from "some at church, friends of friends, even parents of my kids' friends."

She's also helped people get high-tech computer jobs that are completely incomprehensible to her. As the irrepressible volunteer puts it, "My resumes usually at least get them in the door."

After an exciting career writing science for National Geographic*, Donald J. Frederick retired and did what many writers do. He began a new career freelance writing in Washington, DC, and* Chemistry *is proud to have him as a regular columnist.*

CHEMISTS MAKING MUSIC

Chemistry and music may seem an odd duo, indeed. But music has a home in the brains of many chemists and other scientists, including individuals who perform at world-class levels. What explains the link between pursuits that seem a million miles apart?

BY JOAN STEPHENSON, Ph.D.

Home in the Brain

(Sung to the tune of *Home, Home on the Range*)

Oh, give me a brain
with the dendrites free reign
to connect and forever to play;
Where music is heard
to reinforce every word,
and all sorts of knowledge to gain!

Home, home in the brain
Where the dendrites have free reign
to connect every thought
just the way they were taught
without any struggle or strain.

—Lyrics by Illinois school teachers Matt Owens (ACS '95), Mary Jo Loffelmacher, Sharon Martin, and Lisa Owens. From Songs for Teaching (www.songsforteaching.com/Science.html)

One enduring image from the annals of pseudoscience is the "phrenological head," a map subdivided into plots indicating the hypothesized location of a person's strengths, weaknesses, and proclivities—a patch of "mindfulness" here, a blob of "wit" there, a rectangle of "causality" there.

Although phrenology has long been abandoned, a modern-day practitioner surveying scientists, engineers, and mathematicians for interests and talents would be likely to devote substantial portions of cranial real estate to science, mathematics, and music.

Music has a home in the brains of many successful scientists, including those performing at impressive musical levels. A look at the "day jobs" of competitors in the Van Cliburn Foundation's latest International Competition for Outstanding Amateurs shows that about one-third of the 73 participants were physicians or other health professionals, engineers, computer experts, and scientists—including two chemists, one of whom tied for first place.

The fact that there are so many musically talented scientists raises some intriguing questions about a possible link between science and music, such as whether there's an overlap of skills that contribute to an affinity and ability for both music and science, or if early training in music can affect the developing brain in ways that contribute to scientific abilities.

Dual gifts

Chemists with music on their minds have made their marks in both disciplines. Perhaps the field's most prominent chemist–musician was Alexander Borodin, who achieved distinction as both an organic chemist and a composer of symphonies, chamber music, and the opera *Prince Igor*.

"Borodin was a really good and insightful organic chemist," said ACS past-president Ronald Breslow (ACS '51), a distinguished chemist and musician in his own right. Another distinguished composer, Sir Edward Elgar (known for "Pomp and Circumstance" and the "Enigma Variations") was a keen amateur chemist who conducted experiments in a home laboratory.

A remarkable number of modern chemists also have demonstrated a talent and affinity for music. Chemist and inventor Arnold O. Beckman (ACS '27), who founded Beckman Instruments, performed as a movie-house pianist and started his own orchestra in high school. Nobel laureate Jean-Marie Lehn (ACS '62), who plays the

piano and organ, reportedly has three pianos at home, including a Steinway he bought with his Nobel Prize money. And the late Donald Cram (who shared the Nobel for chemistry in 1987 with Lehn and Charles Pedersen), carried firewood, emptied ashes, and shoveled snow for music lessons and later played the guitar to break the ice in chemistry classes he taught.

For some, the siren song of music finally exerts an even greater pull than science.

Victoria Bragin (ACS '90) began studying piano at age 8 in her native Philippines. Chemistry came into the picture after she sailed through senior-level college music courses and earned a music diploma at age 16. She earned a master's degree in chemistry at the University of Wisconsin, where she met her future husband, a fellow chemistry student. Music remained a vital part of her life, a welcome counterpoint to her work as a chemistry professor at Pasadena City College and subsequently as a program director in the National Science Foundation's Division of Undergraduate Education.

But winning first prize in the Van Cliburn amateur competition in 2002 marked the turning of the tide. Now Bragin is largely retired from chemistry and is relishing her new role as musician-in-residence at the Huntington Museum of Art in West Virginia.

Common ground?

Pianist–violinist–chemist Melvin Chen, who earned a doctorate in chemistry from Harvard University and a double master's degree from Juilliard in violin and piano performance, has the unusual distinction of being both a professor of music (at Yale University) and a visiting professor of music and chemistry at Bard College. An ebullient Renaissance man, Chen sees much common ground between science and music.

"For me, they're both ways of searching for knowledge in the world and the truth of the human experience," he said. "Science looks at how the world works in a systematic way; art comes at it in a complementary way."

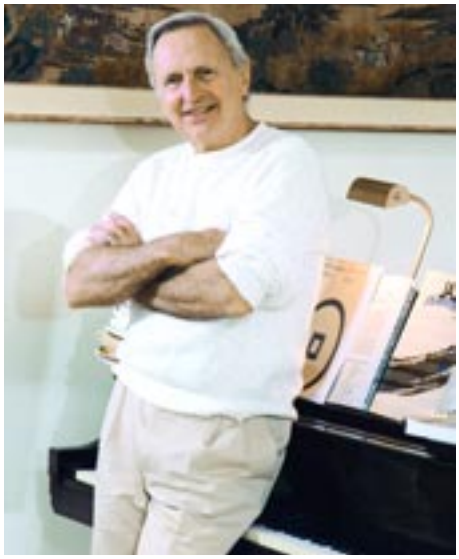
Chen explained that both performing music and doing science require discipline and a certain ability to take individual pieces of data or individual notes and synthesize them into something coherent.

"It's important to concentrate on both the little things and to see the big picture, to focus on both the specific and the general," he said.

Music and chemistry also have in common the fact that they use abstract symbols, which combine into an abstract language, said Chen.

Experts who study how the brain processes music agree. Musicians and mathematicians both excel in manipulating abstract symbols.

VICTORIA BRAGIN (ACS '90) began studying piano at age 8 and won first prize in the 2002 Van Cliburn amateur competition.



RONALD BRESLOW (ACS '51), a talented pianist, has been known to "bump guys off pianos in bars" for a chance to play.

"Whether it's using numbers or using musical notes or using letters, one has to be able to string those symbols together in a way over time that conveys some sense of meaning," said Mark Jude Tramo, director of the Institute for Music & Brain Science at Harvard Medical School, who both plays guitar and composes. "One of the great talents that terrific musicians and chemists have is the ability to see beyond the immediate next step in a sequence."

For some chemist–musicians, music provides a catalyst that facilitates their ability to leap ahead mentally.

"I've found music helpful when I was working in the lab," said Chen. "When I had a problem that I couldn't figure out, I would practice the piano for a while and find I'd have the answer—who knows how?"

Playing music can be a relief from doing science because it engages the brain in a way that is not consciously analytic, said Breslow, who favors improvisational playing and claims to be "infamous for bumping guys off pianos in bars" to play. Breslow's love of music and talent as a pianist are so well known to colleagues, in fact, that they commissioned a piano composition for an an all-day symposium held in 2001 to mark his 70th birthday and contributions to chemistry.

The title: "Liberating Chemistry from the Tyranny of Functional Groups."

Though music is "enormously relaxing," said Breslow, the analytic part of the brain may be working quietly in the background.

Music and the brain

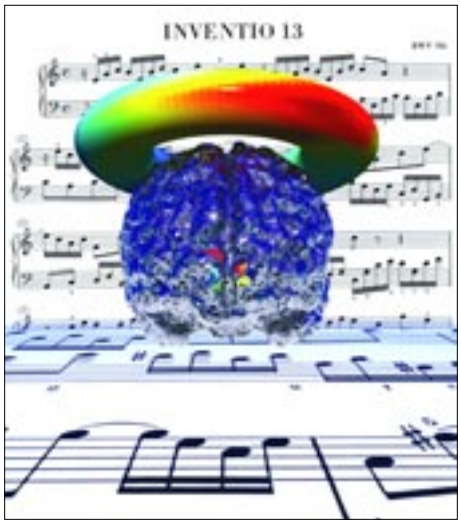
In recent years, there's been a flowering of research, much of it by neuroscientists who are skilled musicians themselves, into how the brain processes music and music's effects on the brain. Researchers who study the brain stress that while it's possible to localize some aspects of music processing to specific regions of the brain, listening to and playing music are complex processes that involve memory, learning, emotion, and (especially for playing) motor skills, making it likely that many areas of the brain are important in experiencing the emotional riches of music.

Just the act of listening to music is an impressively complex activity. "People have no idea just what geniuses they are in terms of what they do when they turn on the radio and listen to music," said Tramo. The operations involved in apprehending the emotion of a Mozart concerto, for example, are very complex, and are carried by a kind of relay system in the brain, he explains.

First, the brain collects and processes sensory input, the kind of data that reaches the retina or the ear. Scientists have known for some time that the part of the brain that receives sensory input—sight, sound, touch—lays this information out in a map-like way, which enables the brain to process relative distances between, say, two objects.

Recently, neuroscientist Petr Janata and colleagues at Dartmouth College found the brain not only maps individual pitches (frequencies) but also the 24 major and minor keys in Western music, some of which we perceive as being more similar to each other than others. Janata and his colleagues used a brain imaging technique called functional magnetic resonance imaging (fMRI) to track the brain activity of volunteers as they listened to a tune that moved through all 24 major and minor keys in Western music. "We found that the distance relationships among the keys (how similar or different they are to each other) can be represented on the surface of a torus, a donut shape," he said. (See graphic.) This map for musical activity is in an area in the front of the brain that some researchers suggest plays a role in introspective thinking.

PETR JANATA found that the brain not only maps individual pitches (frequencies), but also the 24 major and minor keys in Western music.



MUSIC ON THE MIND, depicted in a graphic from Petr Janata's group, which found that the distance relationships among the musical keys (how similar or different they are to each other) can be represented on the surface of a torus, or donut shape. The group has found and mapped the area in the brain that processes and tracks music. This location is also active during reasoning and memory retrieval. Janata´s group used functional magnetic resonance imaging (fMRI) to map brain activity while volunteers listened to a piece of original music. The fMRIs indicated that knowledge about the harmonic relationships of music is maintained in the rostromedial prefrontal cortex, which is centrally located, right behind the forehead. This region is connected to, but different from, the temporal lobe, which is involved in more basic sound processing. The region is important for a number of functions, such as assimilating information that is important to one's self, or mediating interactions between emotional and non-emotional information.

"To some extent, a certain amount of introspection and creative character in science is consistent with music," said Breslow. "Both performing and doing science require a lot of time alone." To keep one's skills polished, he said, musicians require practice time alone, and "science, to some extent, is a lonely profession that requires a lot of sitting quietly and thinking about what things mean."

Playing an instrument or singing makes additional demands on the brain. Skilled musicians require impressive motor skills, and the movement of fingers, hands, arms, lips and so on is directed by specialized motor areas of the cerebral cortex. The brain also has to integrate the sound a musician is producing and movement, interpret touch information (from fingers or lips and mouth as they work an instrument), and process the emotional response to music.

Lisa Saunders Baugh (ACS '90), a polymer chemist–violist–violinist who recently joined *Chemistry*'s editorial board, said she isn't surprised that performing music appeals to many scientists. She is with ExxonMobil Corp. Strategic Research in Annandale, NJ.

"Scientists like to think about multiple things, to be challenged," said Baugh, who plays violin and viola in chamber music groups and with the Central Jersey Symphony (a semipro group) and a community orchestra. "Playing in an orchestra takes every ounce of concentration you have," reading the music, watching other people, making precise physical movements with arms and fingers, and matching the sound of one's instrument with that of 70 other people. This intense focus "totally wipes everything else out of my mind," said Baugh. "It's the only thing that is intense enough to do that."

Douglas C. Neckers (ACS '59), a photochemist at Bowling Green State University,

agrees that an intense focus is something science and music have in common. He sings in an Anglican professional choir that travels to England to perform in some of the country's great cathedrals when the resident choirs are on vacation.

"You have to be very intense to be successful in either discipline," he said.

The brain interprets the auditory information it receives, an activity that involves processing many types of information in addition to the auditory data. The common final pathway in this network of relay stations leads to the ancient structures in the brain that function as the organ's emotional centers, said Tramo, and the resulting emotions are the embodiment of the aesthetic experience.

Common threads

Some scientist–musicians suspect that an appreciation for logic and structure, as well as an affinity for mathematics, may be a common thread in science and music.

"There is a logic to music and there is an art to science," said Kenneth Jolls, a professor of chemical engineering at Iowa State. He's an accomplished vibraphone player who's performed with symphony orchestras, jazz bands, and other groups. Jolls recently performed and talked about the physics of the vibraphone at the Cornelia Street Cafe in New York's Greenwich Village as part of a monthly program called "Entertaining Science."

Organized by Nobel Prize-winning Cornell University chemist and poet Roald Hoffmann (ACS '63), the evening brings together the realms of art and science—realms that have human creativity in common. Jolls needs no persuasion that the arts have a role to play in science education. "Nowhere is there a better example of art in science than in classical thermodynamics," a subject he teaches. Visual images of thermodynamic models "give you semitangible entities to tie to things that are perceived otherwise in the blind abstract," he said.

PHOTO BY SUSAN WILSON

MELVIN CHEN, renowned pianist–violinist–chemist, earned a doctorate in chemistry from Harvard University and a double master's degree from Juilliard in violin and piano.

On the other hand, he finds a grasp of the abstract also provides a dimension to music. "I was formally a theory major in music school, and a mathematical mind certainly helps one appreciate the order and regularity of music," explained Jolls.

David Schuster (ACS '56), an organic chemist at New York University and an accomplished pianist, said that both disciplines have an aesthetic appeal. "We talk about a piece of research as 'an elegant piece of work'," said Schuster, whose particular treasure is his "magnificent 7-foot Steinway grand piano," an instrument previously owned by publishing magnate Alfred Knopf. "An idea that is 'elegant' has inherent appeal and beauty." Part of that beauty can be related to how a piece of music or research is put together, he said.

"It takes an organized mind to play piano," said Schuster, who sometimes brings a score to concerts to see how the music fits together. "You have to learn how to put together the logic of it."

Breslow seconds that idea.

"Music has a wonderful interior structure," he said. "For a scientist, music is a reminder [of] how much interesting structure there is in the world."

"There's a lot of math to music," said Tramo. "If you have to change from one key to another, if you have to learn the fret board of a guitar or a piano, you're always dealing with distances, scalar magnitudes, ratios, relationships among notes, things that are very much related to simple and recursive operations that go into a lot of what we think of as math." But different forms of math, and different aspects of the complex activity of music, involve different parts of the brain, he said.

Thus, something like algebra would be apt to involve the left hemisphere, which is specialized for speech, writing, language, and calculation functions, while geometry, which involves spatial information, is likely to involve the right hemisphere, the side dominant for spatial abilities. The same is likely to be true for music, so that activities like playing by ear, composing, reading music, or singing songs will recruit different areas of the brain.

Craving music

Why do humans have the capacity to make and enjoy music?

The topic intrigues researchers. Some suggest music is just a serendipitous evolutionary by-product of other perceptual and motor abilities that are crucial for survival. Others suggest that music's ability to enrapture, send shivers down the spine, and bring tears to the eyes might promote our physical and mental well-being.

"One can't escape the fact that music is something our brains seek out," said Janata.

Researchers at the Montreal Neurological Institute and Hospital have found that music activates neural pathways in the brain that are associated with euphoria and reward, areas that are activated by pleasurable activities such as eating or sex. It's possible that music lowers stress by activating parts of the brain that make us happy. There's also a lot of anecdotal information suggesting that music might have a role in pain management, in treating premature infants, and in lowering blood pressure, said Tramo.

One hypothesis suggests that music evolved to promote social cohesion. "Humanity would never have made it if it didn't form bonds, so there has to be a set of events that we can all share," said Tramo. "Look at our culture, there's nothing humans do, not even a baseball game, that doesn't involve some ritual related to music."

DOUGLAS C. NECKERS (ACS '59), a photochemist at Bowling Green State University, sings in an Anglican professional choir that performs in the United States and the United Kingdom.

Is Music Good Cross-Training?

Neuroscientists have detected a number of structural differences in the brains of musicians; these findings suggest that musical training can influence brain organization and ability.

- Several areas of the brain are larger in adults who play musical instruments than in nonmusicians. These include areas such as the primary motor cortex and the cerebellum, which are involved in movement and coordination, as well as the corpus callosum, a large band of nerve fibers that links the two hemispheres of the brain.

- A larger proportion of the auditory cortex (which brings music and speech into conscious experience) responds to piano tones in adult musicians as compared with nonmusicians. The earlier the age at which the musicians had begun lessons, the more enlarged the area. Follow-up research revealed that the brains of musicians are especially attentive to the sounds of the instruments they play; a larger area of a violinist's brain responds to hearing violin sounds than it does to hearing trumpet sounds, and vice versa.

- In trained violinists, the area of the somatosensory cortex (which interprets touch information) corresponding to the four fingers used to press down on violin strings is enlarged.

- Trained musicians tend to use more of the left, analytical half of their brains for processing music than nonmusicians.

Scientists are also studying whether the brain changes seen in musicians enhance mental functions not associated with music—in other words whether music serves as a kind of cross-training for the brain.

- Adults with musical training perform better on word memory tests than other adults.

- Preschoolers who have had piano lessons for about six months perform better than their counterparts on puzzle-solving tests.

- Second-graders who played special computer math games and took piano lessons scored higher on math tests than students who played the same computer games but had English language instruction rather than piano lessons.

- Children who had musical training for one to five years had significantly better verbal memory than schoolmates without such training—and the longer the training, the better the verbal memory. The researchers suggest that music has a kind of cross-training effect: The extra stimulation from studying music to the left hemisphere of the brain, the side that handles language, boosts its ability to handle other left-hemisphere functions, such as verbal learning.

- "There's no way to tell if such studies have something to do with specific cognitive functions involved in music and math," said Tramo. "Or they may relate to other so-called general purpose cognitive mechanisms like attention, memory, that are involved in language and all sorts of other cognitive activities. But they do suggest that music can tap into brain mechanisms involved in these other processes and can conceivably improve them."

—JS

Many chemist–musicians would endorse the notion of music as an opportunity to connect with other people. Frank Mallory (ACS '58), an organic chemist–clarinetist at Bryn Mawr, belongs to an kind of pick-up group of like-minded scientist–musicians called the Borodin Ensemble. It includes fellow organic chemists David Schuster and Jerrold Meinwald (ACS '49), from Cornell. Mallory also plays chamber music at Bryn Mawr and spends a portion of each summer in Bennington, VT, playing at a chamber music conference.

When Meinwald is invited to speak at meetings or give a seminar, he offers to throw in a program of chamber music featuring himself on flute, his wife on piano, and any local talent that can be lined up.

"Playing music provides an opportunity to interact with musicians of any age and from entirely different walks of life," explained Meinwald, a septuagenarian who studied with legendary French flutist and teacher Marcel Moyse. "I have very little in common with a college freshman, but when playing music, that doesn't matter. You can have absolute rapport."

Other researchers suggest that music and language co-evolved and are closely entwined. "Pitch and melody are used to convey meaning; the very nature of human and vocal communication is musical," said Tramo.

Whatever the reason music evolved, and whatever links music shares with the scientific enterprise, the main reason scientists crave music is the same as for us all. It makes us feel good.

"Science is intellectually challenging, and there are scientific sides of music which are certainly important intellectually," said Jolls. "But the reason I play and listen to music is because it sounds so good.

"I don't think I would ever shed a tear over science, but anyone who understands what's going on in some of the Verdi and Puccini operas and keeps a dry handkerchief all the way through—well, welcome to the grave."

Joan Stephenson found this topic right in her bailiwick. A Chicago-based science writer who has a Ph.D. in biology, she is a flutist. One of her brothers is an astrophysicist and bassoonist, and the other a chemical engineer who plays the saxophone.

FRANK MALLORY (ACS '58), an organic chemist–clarinetist at Bryn Mawr, plays in the Borodin Ensemble, a group of scientist–musicians.

Periodic Table of Music

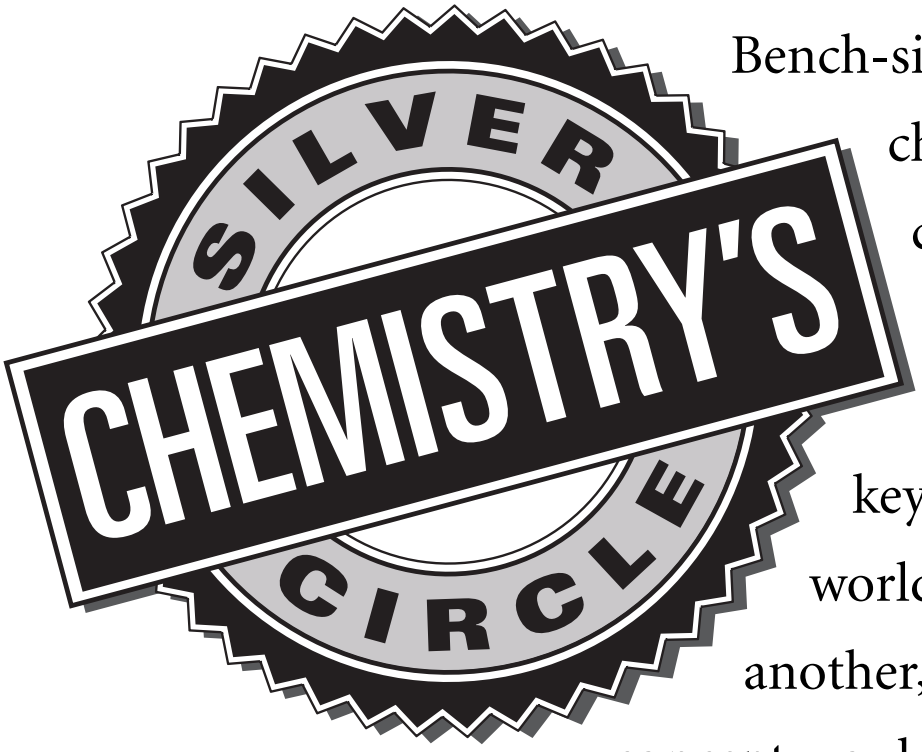
In 1863, English chemist John Newlands proposed the "Law of Octaves," after arranging the elements in order of increasing atomic mass. With a nod to Western music, he suggested that chemical properties also repeat with every eighth element.

The basic scale in Western music has a periodicity of eight notes, an octave. Newlands' theory was largely met with scorn, and soon it was eclipsed by Dmitri Mendeleév's proposed periodic table of the elements in 1869.

But much of it proved to be true. Newlands' system works for the lighter elements, because eight electrons complete the outer shell, but failed to work for the transition metals.

—JS

JERROLD MEINWALD (ACS '49) (right), a Cornell organic chemist and Borodin member, studied with legendary French flutist Marcel Moyse. Thomas Eisner (left), the Jacob Gould Schurman Professor of Chemical Ecology at Cornell, is at the harpsichord.



Bench-side research is one way chemists stay active and connected with the central science after traditional retirement age. Filling key positions with the world's top scientific society is another, and the "Silver Circle" concept would encourage it.

BY RACHEL SMOLKIN

Ray H. Crist (ACS '26) leaves his central Pennsylvania home in Carlisle around 7:30 a.m. every day and heads for his lab at Messiah College in nearby Grantham. There he uses atomic absorption spectrometry to study uptake of metal ions by algae, peat moss, and other plants that could be used in environmental remediation projects. Home beckons by 6 p.m. For a bench-side chemist, there's nothing unusual about Crist, except for one thing: He is 103 years old.

Crist is among those chemists who continue contributing to the central science long after reaching the traditional age for retirement. They've been thrust into the spotlight since 2002, when John B. Fenn (ACS '41), a Virginia Commonwealth University professor, won the Nobel Prize in Chemistry at age 85. Many others, however, no longer do bench-side research. They labor for rewards that pack a Nobel-sized wallop of a different sort—the smile of a child they've tutored, the gratitude of a younger chemist they've mentored, or the knowledge that they are helping sustain the ACS.

Their basic contribution involves time, the precious commodity that people can't spare earlier in life, when young families, career development, and other demands weigh so heavily. These chemists give it behind-the-scenes, often unnoticed and unrecognized. Their contribution takes many forms: helping hook kids in local schools on careers in chemistry, advising chemists with newly-conferred degrees about career development, lobbying for state and federal legislation that affects science, or serving in an array of ACS positions in Technical Divisions, Local Sections, and at the national level.

Members of this special breed of chemist invariably gain personally and professionally (see sidebar, page 27) from their work. It keeps them connected with chemistry, for instance, and gives them the satisfaction of seeing their life experiences benefit new generations of chemists.

Jerry Bass (ACS '57), 70, retired from Virginia Commonwealth University as a chemistry professor and now chairs the ACS Membership Affairs Committee.

He said that retired chemists "have a lot to share." He added, "They have administrative experience and all sorts of life experience. They know where the problems are and the pitfalls, what can be workable and what's not. They know what's been going on for the last 30 or 40 years." Retired chemists not only provide valuable insights, Bass said, but also can spare hours for vital and time-consuming governance functions at the ACS. "It keeps them active," Bass added, "and it helps the society."

RAY H. CRIST (ACS '26) remains active in benchside chemistry at age 103, offering one model of staying connected with the Central Science. Volunteerism offers another way to continue involvement with chemistry long after traditional retirement time.

The "Silver Circle" concept

Science, like society itself, is taking on a few touches of silver in its tresses, as thousands of Baby Boomers with scientific degrees approach retirement. Like other scientific organizations, the ACS is recognizing the loss that would occur should those individuals simply disengage from chemistry. All too often, that was the pathway for retired chemists in the past. On one level, it would be a massive loss to science, involving lifetimes of scientific expertise, interpersonal skills, and management ability. On another, it would be a loss of members whose contributions are essential to sustaining and guiding the ACS through the early decades of the 21st Century. The prospect of those losses led the ACS to explore new ways of encouraging older members to keep in touch with science and stay active in the society.

A task force concluded in 2002 that the ACS has the resources in place to serve retirees in areas ranging from workshops on consulting to group travel programs. The task force suggested that local sections could play a critical role in serving and engaging older chemists. Other members, including Eli M. Pearce (ACS '49), the immediate past-president of the ACS, want to see the national office adopt an expanded role. Pearce, 74, noted that 20 percent of ACS members are over age 60. He envisions a "Silver Circle" of senior members—a Washington, DC-based program that would guide efforts to keep senior members active. "I see a lot of people fumbling around and trying to figure out how to get involved," Pearce said. "We should make it easy for them to do it."

Keeping up with chemistry

When older chemists do find fulfilling ways to contribute, they say their efforts bring them deeper personal satisfaction and keep them engaged in the scientific community.

"The American Chemical Society has been my way of keeping up with what's going on in my profession," said Celia Marshak (ACS '49), 80, an emeritus professor in the College of Sciences at San Diego State University. She has been active in her local section since 1972, serving as a secretary, a chair, and a councilor representing her chapter at national meetings. During the 1980s, she served on the Women Chemists Committee and the Minority Affairs Committee.

Marshak recently cut back on her activities to make room for new leaders. But she still attends occasional ACS meetings.

George Hammond (ACS '44), 82, the photochemistry pioneer and Othmer medalist, described how ongoing relationships with various universities enable him to maintain contact with students and research. He recently taught a graduate course in technical writing at Portland State University and also critiques research by graduate and postdoctoral students at Bowling Green State University (BGSU) in Ohio. Retired chemists may not realize how modern technology makes those long-distance relationships possible. With a telephone, fax machine, and Internet connection, their retirement homes can be thousands of miles away from their volunteer venues. Hammond, for instance, lives in Oregon and maintains a long-standing relationship with BGSU's Center for Photochemical Sciences by fax, e-mail, and video conferencing. He receives the Bowling Green papers via fax or e-mail and then offers feedback via video conferencing.

"Students benefit from Hammond's knowledge, ability to think critically and analyze and write well," said Douglas C. Neckers (ACS '59), executive director of the BGSU photochemistry center. "He's one of the most celebrated chemists of his generation, and is tireless in helping the next generation." When the Chemical Heritage Foundation awarded Hammond the 2003 Othmer Gold Medal, President Arnold Thackray (ACS '80) said that he is "widely credited with creating the discipline

Silver Circle

"I think it's very important…for me to let these young ladies know that they can do this. We're going to need these women in the future."

—JUDITH MARIE IRIARTE-GROSS

VOLUNTEERING: Not for Retired Chemists Only

While many retired chemists donate time to the ACS, chemists of all ages and backgrounds take pride in their ACS ties and volunteer work. They cite many reasons for volunteering—delight in nurturing young chemists and stimulating the public's interest in science, gratitude for friendships forged through the ACS, and appreciation for the enhanced skills that volunteering can bring. Here's a look at just a few ACS projects and volunteers:

Malika Jeffries-El

When Jeffries-El (ACS '98), 29, started attending ACS meetings several years ago, she quickly realized she could bring fresh perspective to the organization. "I don't fit the mold at all of what people think an ACS member is: I'm young; I'm female, and I'm black," said Jeffries-El, a postdoctoral research fellow in the chemistry department at Carnegie Mellon University in Pennsylvania. She joined the Younger Chemists Committee to help diversify the ACS membership and works to make programming more relevant to peers completing school or launching careers. Jeffries-El and other committee members have created programs such as "Graduate School Reality Check," "TA: What Am I In For?" and "The Two-Body Problem" for young dual-career couples searching for jobs in the same location. She hopes to encourage young chemists to take a more active role in the ACS and said her volunteer work has introduced her to many outgoing, dynamic young people in her field.

Sharon Loretta Haynie

Haynie (ACS '77), 48, has spent nearly a decade helping low-income students in her lab "look beyond the world in which they live." Haynie, a chemist with DuPont in Wilmington, Delaware, is a mentor for an ACS program called Project SEED, which provides summer research internships and lab experience for economically disadvantaged high-school students. "I've enjoyed it immensely," she said. "It's my way of giving back. I had sought an opportunity like that when I was a kid growing up in Baltimore, and I was never able to get something like that. It's a way of helping students who may be in circumstances a little like mine. …Hopefully it will inspire them to be a little more creative and willing to push the envelope for themselves."

Judith Marie Iriarte-Gross

"Ooze, Goo, and Slime." That's the name of a polymer seminar that Iriarte-Gross (ACS '83), 50, gives each year to middle-school girls as part of a program called Expanding Your Horizons in Science and Mathematics. Iriarte-Gross, an associate professor of chemistry at Middle Tennessee State University, is a new member of the Women Chemists Committee and a longtime local organizer of Expanding Your Horizons (EYH), created by the Math/Science Network—and supported by the ACS—to nurture girls' interest in math and science. "It gives you a thrill to get these young ladies talking about science," Iriarte-Gross said. "I think it's very important…for me to let these young ladies know that they can do this. We're going to need these women in the future." The girls ask all kinds of questions, including how many years Iriarte-Gross studied to get her degree and whether she's married (The answer is Yes: You can be a scientist and have a life, too). "Is your name really Dr. Gross?" they want to know. "Or is it just because you make slime?"

Michael Sheets

As a National Chemistry Week task force member and local coordinator, Sheets (ACS '93), 52, helps plan future themes. The 2004 theme is Health; in 2005, it's The Chemistry of Toys. Sheets also suggests demonstrations that Student Affiliates can share with school children, including filling film canisters with Alka-Seltzer tablets and water to launch pop rockets. A chemistry professor at Texarkana College in East Texas, Sheets worries that many children seem to lose interest in chemistry as they grow older, and many adults seem to regard it as something scary. "I want to communicate the excitement of chemistry and science to these kids," Sheets said. "Chemistry is not a dirty word….Chemistry is the world around us, and it's a tool for us to use. The more informed we are, the better decisions we can make."

Anthony M. Noce

Noce (ACS '91), 38, recently finished his second stint as chair of the ACS Northeast Regional Meeting. He also serves on the Committee on Environmental Improvement and, as the incoming 2004 program chair for the ACS Environmental Division, will plan environmental programming at national meetings. A personal passion is sustainability. "The best remediation is not to contaminate the soil and groundwater in the first place," said Noce, a supervising chemist and senior project manager at MWH Americas, an environmental engineering and consulting firm. He said his ACS volunteer commitments have helped him forge friendships and develop new skills, including handling a large budget and working with a diverse group of people toward a common goal. "If you can do that in the volunteer setting and figure out how to do it effectively, [it] really helps in the professional setting," Noce said.

Kendrew H. Colton

Colton (ACS '79), 48, chairs the Chemistry and the Law Division at the ACS and also serves on the Committee on Patents and Related Matters. A patent attorney in Washington, DC, Colton fosters and helps develop national meeting programming addressing the intersection of science and law. He has participated in programs such as "Patenting Chemical Compounds," "Legislative Developments Affecting Biotechnology," and "The Attorney Is In: Question and Answer Period." He praises the people he's met through the ACS as "tremendous…everyone's got different life experiences and offers a different perspective."

Badal Saha

Saha (ACS '89), 54, chaired the ACS Peoria Section in Illinois in 2001. He appointed a minority affairs coordinator, and together they created career fairs at three local universities to stimulate minority students' interest in chemistry and science. "Minority students are very underrepresented in our community," said Saha, a native of Bangladesh. A research chemist at the U.S. Department of Agriculture/Agricultural Research Service, Saha said he enjoyed interacting with the students and wants to cultivate young talent.

—RS

of organic photochemistry." Hammond was a professor for three decades at Iowa State University, the California Institute of Technology, and the University of California at Santa Cruz; he then spent ten years as a research director at Allied Signal (now Honeywell) before retiring in 1987.

Orchestrating new careers

Richard Brandt (ACS '52), 73, also looked for ways to remain engaged professionally after his retirement. As a volunteer ACS career consultant, Brandt reviews resumes for chemists of varied ages and stages in their careers. Some resumes come from chemists who have lost their jobs because of downsizing, mergers, or cutbacks in a sluggish economy. "I was laid off three times through my experiences in private industry, so I can relate to what people who are going through it are facing," Brandt said. "I felt that maybe I had something to offer and could give people a little encouragement when they need it."

Brandt eventually left private industry to work in the national laboratories, spending time at Los Alamos in New Mexico and Lawrence Livermore in California before retiring in 1991 from Hanford Nuclear Reservation in Washington State.

"I have lived all over the country, so I can relate to a lot of different areas," Brandt said. He receives most resumes from the ACS Career Services office via e-mail and corresponds several times with each candidate, offering suggestions about format or style, answering job-search questions, and providing descriptions of possible locations.

Robert Allan Pett (ACS '66) uses his 35 years of career experience in rubber research as a councilor for the ACS Rubber Division, one of 34 technical divisions that foster professional development and education and provide arenas for exchanging ideas. Pett, 63, has been active in the Rubber Division since the early 1970s and chaired it in 1988. He has recruited speakers for technical symposiums, chaired symposiums and participated in the program-planning committee, and helped pick textbooks and subject content for Division correspondence courses.

ROBERT ALLAN PETT (ACS '66)

Pett, who lives in the Detroit suburb of Franklin, Michigan, retired from Ford Motor Company in 2002. He also is a member of several other ACS technical divisions, including Environmental Chemistry and Industrial & Engineering Chemistry. "Keeping abreast with the changes in the technical area has been very important, but equally important has been the association with absolutely tremendous people," Pett said.

For Mary F. Singleton (ACS '76), 67, retiring as a research chemist from Lawrence Livermore National Laboratory brought an opportunity to explore a long-time interest—collecting historical data on women in chemistry. "We need to be doing the history of our women scientists," Singleton said. "We do so much on outstanding men in science, but women in science fall through the cracks. Few outstanding women in science get interviewed or get their oral histories done."

Singleton set out to change that. She began to collect the oral histories of the first women scientists who came to Lawrence Livermore in the 1950s and 1960s. "It's a very unique place," said Singleton, who retired in 1996 as the deputy plutonium facility manager. "Lots has been written about the men who worked there, but very little about the women. Those women have wonderful stories to tell, and they did important work."

She soon expanded her exploration, researching women chemists who worked with the late Dorothy Hodgkin, the Nobel laureate who deciphered the structures of penicillin, insulin, and vitamin B12. Singleton also wrote an article on the history of women chemists in California for a local ACS publication.

Singleton believes her own passion for chronicling women's scientific accomplishments benefits her local ACS section and the Women Chemists Committee on which she serves. She not only acts as a resource for others but also uses her contacts to recruit interesting speakers to local meetings.

"I've met some women who are older than I am, which has been very rewarding," Singleton said. She's also been able to mentor some younger women in the field, including a woman at Los Alamos National Laboratory who is researching the history of women scientists there. "I'm still in the learning mode on oral histories," she said, "but I'd like to do a lot more serious work in it and even get more training."

Bob Martin (ACS '48) also used retirement to pursue new interests. Martin took early retirement from DuPont when he was in his early 60s but decided he wasn't finished with science. "I had good health, and I enjoy chemistry," said Martin, 79. "I thought I could still contribute and if I could help these young people coming through, particularly with my experience in industrial chemistry, that it would be worthwhile."

So he came to Messiah College, which he and his brothers and sisters had attended when it was still a junior college, and has stayed for 17 years. Initially he taught in the classroom. Now he helps teach the analytical chemistry component of an advanced experimental lab course. Martin, an ACS member for more than 50 years, also checks that the analytical instruments are working properly and chairs the department's safety and industrial hygiene committee, which ensures that students and faculty members engage in safe laboratory practices. Like Crist, he donates his services for $1 a year.

The Crist pathway

In some ways, Ray Crist may be the model for Baby Boomer chemists approaching retirement. With life expectancies growing, they can expect to spend a big proportion of their lives in retirement. Many may retire multiple times. A large number might want to remain connected to their careers and continue to contribute to science.

In June, Crist's son Henry prepared some remarks to offer in his father's honor during a ceremony for the Dickinson College Alumni Lifetime Achievement Award. He never delivered the remarks—his father decided to speak himself—but Henry's prepared text offers insight into Ray Crist's longevity and unquenchable passion for volunteer work and research.

"It is my curiosity," Henry Crist quoted his father as saying. "I cannot stop it. I can't help but wonder at everything I see. What makes it be that way? And so I just want to find out. There is so much more I want to do."

Born in 1900 on a farm near Grantham, Crist has retired several times in a remarkably varied career. He received his Ph.D. from Columbia University and then taught there. He joined the ACS in 1927, worked on the Manhattan Project that built the first atomic bomb, and then directed the now-defunct Union Carbide Research Institute in Tarrytown, New York. At 63, he retired and joined the faculty at Pennsylvania's Dickinson College, his undergraduate alma mater, to teach the history and philosophy of science to nonmajors. Having reached Dickinson's mandatory retirement age at 70, he went to Messiah College, where he has remained for 33 years. Until age 85, he guided college students in environmental projects. Then Crist switched to full-time lab work. He earns $1 per year.

Silver Circle

"It is my curiosity, I cannot stop it. I can't help but wonder at everything I see. What makes it be that way? And so I just want to find out. There is so much more I want to do."

—RAY H. CRIST

The volunteer gateway

The ACS website (chemistry.org) is the gateway for information for many volunteer positions with the society, with information about everything from seeking elective office to serving on governance and other committees.

Also on the site are tools that can help in less-formal, grass-roots activities that are important to the future of the ACS and chemistry as a science. For instance, many ACS members, including several profiled in the sidebar accompanying this article, subscribe (via http://congress.nw.dc.us/chemical/home/) to the Legislative Action Network (LAN). That e-mail bulletin keeps members informed about federal science legislation and prompts them to voice their opinions to their local representatives in the U.S. Congress. U.S. Senators and Representatives track their mail from constituents carefully, because each letter means a vote potentially lost or gained. That makes informal lobbying on the local level a high-impact activity.

Rachel Smolkin, although nowhere near retirement, got some valuable tips for the future while researching and writing this project. A freelance writer in Washington, DC, Smolkin is a regular contributor to Chemistry.

STICKY SCIENCE:

ADHESIVES & GLUES

People have searched for the secret of stick for centuries, and still things won't stick and stay stuck. The consequences range from that delaminated running shoe to the crash of a space shuttle. Sticky science is responding to the challenge with solutions like "adhesives with a brain."

BY ELI KINTISCH

NASA

INSULATION DELAMINATED from Columbia's external fuel tank (in orange) last February, leading to disaster when the shuttle tried to re-enter Earth's atmosphere.

NASA

SPACE SHUTTLE Columbia disaster was a vivid reminder of modern technology's reliance on adhesive technology.

The space shuttle Columbia disaster spotlighted management and cultural problems within the National Aeronautics and Space Administration that led to safety lapses, investigators concluded, which culminated in last February's loss of the shuttle and seven astronauts.

The root cause, however, was a technological predicament that has challenged, puzzled, and perplexed generations of chemists:

How do you get those darn things to stick and stay stuck?

Adhesion of materials is crucial in a society that increasingly relies on lightweight polymers and other materials that can't be held together with traditional fastenings like screws, bolts, and welds. Add to that a huge assortment of paints, inks, labels, and specialized surface coatings that must stick to glass panels and bottles, aluminum cans, semiconductors, and myriad other materials.

Getting things to stick is a crucial but rarely simple proposition.

In the shuttle's case, suspicions quickly turned to failure in adhesion of foam insulation on Columbia's external fuel tank. Investigators concluded that chunks of foam peeled off during the launch, striking and damaging the heat shield covering the airplane-like shuttle orbiter. The shield protects the orbiter from 2,000-degree Fahrenheit temperatures generated by atmospheric friction during descent from orbit for a landing.

Proper adherence requires exacting conditions all along the tank during processing. It is 28 feet in diameter, 154 feet long, and holds cold liquid hydrogen fuel and liquid oxygen oxidizer. The tank must be warmed to 135–150 °F with humidity under 30 percent—requirements that call for special chambers at NASA's high-tech processing facility near New Orleans.

Even the rocket scientists haven't cracked this particular secret of stick. Pieces of the foam have always flaked off during launches, with the typical shuttle getting peppered by about 140 pieces of detached foam. Many are an inch or more in diameter.

Glues and adhesives

Tremendous advances in adhesive technology have occurred. Hobbyists and do-it-yourself types, for instance, have access to inexpensive adhesives that produce joints hundreds of times stronger than those once possible, on a wider range of materials. And a revolution has occurred in industrial and commercial adhesives.

In our imperfect world, however, some sticky things don't always stick, sealants don't seal, glues don't work, and adhesives refuse to adhere. People usually use those terms—"glue" and "adhesive"—interchangeably. Technically, however, there is a big difference. Glues are made from natural materials, and adhesives are synthetic products.

Humans have been searching for stuff that is sticky, stickier, stickiest. Archeologists say that ancient civilizations used tree sap and other naturally sticky materials to repair broken pottery as far back as 4000 BC. Naturally derived glues made from latex, fish, animal hoofs and hides, wheat paste, milk curd, and blood were civilization's mainstay stickers for centuries. Some of these products are still in use and, perhaps surprisingly, are the very best glues for certain jobs. They've been edged out, however, for other tasks by modern synthetic adhesives. These include polyvinyl acetate (PVA) resins found in white and yellow glues, urea resin, epoxy, resorcinol, the cyanoacrylate used in household "superglue," and "hot-melt" glues.

That search continues in the 21st Century, as circumstances intensify the need for better adhesives. With fewer large-diameter trees available, for instance, the construction industry is relying more than ever on veneers, laminates, plywoods, and "engineered" wooden I-beams—all built with adhesive. Electronics manufacturers are using more heterogeneous materials that require high-tech adhesives. Plastic and composite components, which can't be welded, are mainstays in motor vehicles, airplanes, and other products. Constant pressure to reduce production time is also sparking interest in adhesives with new properties, such as fast set-up. Susan Ward, a principal technical specialist at the Ford Research Laboratory in Detroit, said she and her competitors are increasingly turning to quick-drying adhesives on the assembly lines.

Sticky science

Adhesion is also a hot scientific discipline, with more and more fields looking at their problems from its perspective.

DONALD HUNSTON (ACS '65) is a physical chemist who works in the polymers division at the National Institutes of Standards and Technology.

"In the past people thought of adhesion problems in terms of purely structural adhesion," said Lynn Penn (ACS '69), a University of Kentucky chemist who is vice president of the Adhesion Society. Now scientists in fields as disparate as particle physics, biocompatibility, and tissue engineering are closely probing how things stick together, Penn added.

New glues are also changing assembly-line production methods. Epoxy adhesives, for instance, produce joints as strong as those created by welding, but were regarded as too brittle to withstand impact. Now European manufacturers are phasing out welding in lieu of super-tough epoxies that can withstand impact, according to Dave Sweet (ACS '91), market development manager for Dow Automotive (Auburn Hills, MI), a business unit of The Dow Chemical Company. They rely on epoxy toughners, originally developed by adhesive guru Ralph Drake (ACS '65), which use tiny dispersed rubber particles within the epoxy matrix to stop cracks from propagating. Other glues are doing the near impossible. Sweet touts his firm's latest, the Low Energy Substrate Adhesive, which works to "chemically graft" the surface being bonded by extending the length of the polymer chains through a secret polymerization reaction. "You can bond Teflon to Teflon," said Sweet.

Car builders know that adhesives can be even stronger than welding or fasteners. "The advantage in using adhesive is that you have a continuous load path," said Ward. She points to Ford's Aston Martin sports car as a testament to the strength of adhesives. Its frame consists of aluminum and composites held together almost entirely with adhesive.

Sticky challenges ahead

Adhesion remains—you guessed it—a sticky business. Take the challenge of gluing dirty surfaces. Welding works nicely on oily surfaces, said former Ford adhesives researcher Ray Dickie (ACS '63). That's important in the auto industry, where metal parts often arrive at the assembly line coated with films of water-based and oil-based lubricants. Auto companies, operating on tighter profit margins these days, can't afford to add extensive cleaning steps to their assembly lines.

Sweet said newer epoxies could be configured to absorb the offending films, using them as additions to their polymer chains. Polar aromatic additives can help the epoxies dissolve the aqueous lubricants, and nonpolar aliphatic additives can help deal with the oils. Dickie noted that surface contamination still tends to foul the works a bit, though if the glue "meets the engineering standards for the particular application you're looking for, then you're home."

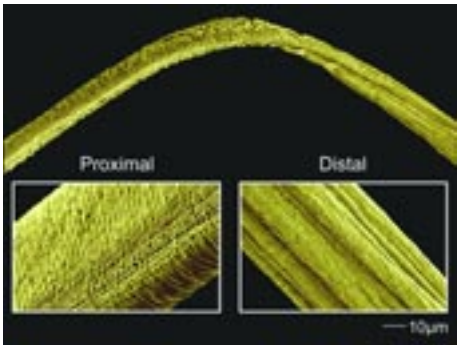
Manufacturers often want glues that work fast so the assembly line can move swiftly, without waiting for parts to set up. But glues that work more slowly can also be advantageous. Ward pointed out that some Ford vehicles have hoods that are built from two pieces and mated for two hours after a strong adhesive is applied. Additives make this possible by causing the adhesive to cure more slowly. Ward's wish list includes a two-part, super-slow adhesive that could be applied but left uncured indefinitely. That way work could be left over the weekend to be completed later. "In an ideal world," she sighed.

New kinds of materials offer novel challenges for the development of better glues and adhesives. Wood adhesive manufacturers, for example, are constantly trying to improve their products' performance on treated woods. Popular treatment products pose challenges for adhesion, according to Chuck Frihart (ACS '68), a chemist with the U. S. Department of Agriculture's Forest Products Laboratory in Madison, WI. Treatment compounds grab some of the wood's surface area, reducing the amount available for adhesives to bond. In addition, copper from the wood preservative is absorbed into the adhesive, forcing the adhesive resin to gel rapidly through a kind of temporary cross-linking. That gives the goo less time to penetrate into the wood. Frihart pointed out that you have to balance adhesives. They must cure slowly enough to penetrate the surface, yet fast enough to avoid long set-up times.

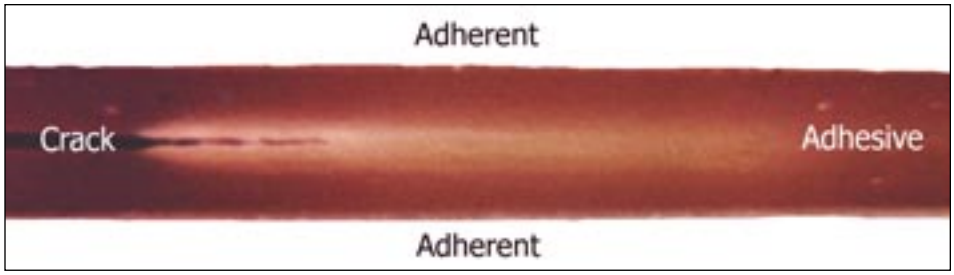
Adhesion's behavior issues

Another challenge facing adhesion scientists is developing models to simulate the behavior of adhesives under stress. Predicting how cracks propagate through bonded joints is complex. Older and simpler fracture theory was based on simple measurements of the energy required for a crack to travel through a bulk material. But cracks forming within a bonded plastic joint travel in hard-to-predict paths.

"The deformations involved are not linear elastic," said Donald Hunston (ACS '65), a physical chemist working as a guest scientist at the National Institutes of Standards and Technology. Now scientists use a model of crack formation designed to reflect the behavior of the area just ahead of the crack, the response of the rest of the bonded joint, and the relationship between the two. This computer-aided approach, known as embedded process zone, leads to extremely accurate modeling of crack behavior in real materials. (See figure.)



MUSSEL GLUE is renowned for its ability to stick to wet rock, wood, and the steel hulls of ships with equal gusto, thanks to L-3,4-dihydroxyphenylalanine (DOPA).



DONALD HUSTON

FRACTURE THEORY predicts how cracks propagate through bonded joints, and a new model of crack formation is providing better information.

Other phenomena in adhesion are not as well characterized. The behavior of soft, pressure-sensitive adhesives (PSAs) like Scotch tape remains difficult to predict. Mechanical measurements of the behavior of the surface of the adhesives are well established, as are details about how the soft, malleable bulk of adhesives behave.

"But a quantitative understanding of how these things work together has been lacking," said Northwestern University materials scientist Kenneth Shull (ACS '86). Toward this end, Shull and others have used a variety of new methods including atomic force microscopy and micromechanical testing to better understand how sticky tape works.

Another rapidly developing area of adhesion science is the subfield of particle adhesion—the study of why particles stick to surfaces and each other.

Consider the problem of understanding why toner adheres to the drum in laser printers and copy machines—a topic of lively debate within the multidisciplinary xerography community. Donald Rimai (ACS '91), principal scientist with printing technology firm NexPress, in Rochester, NY, believes that van der Waals forces keep the plastic bits of toner in place before they are pulled off. Using an atomic force microscope, he and his collaborators have measured the atomic force gradient between toner and drum required to remove the particles—and argued that that gradient matches the relationship called the "power law dependency" of van der Waals forces at low distances. Others believe electrostatic forces are mainly at work. Why does it matter? If the system could be understood and altered, smaller bits of toner could be used, which would translate into sharper copies.

Other work in particle adhesion includes the design of windshields, sunglasses, or computer monitors that might resist the oil and dust particles that float freely in the atmosphere.

Nonstructural adhesion knowledge has important medical applications. Cancer is such a serious disease due to metastasis, a process which occurs because malignant cells don't stick to the original tumor. Rather, they break loose, travel to distant parts of the body, and start growing new tumors. Kimberly Anderson, a University of Kansas chemical engineer, has looked at the role of physical, nonchemical adhesion with a flow chamber that simulates the behavior of cancer cells within a blood vessel. Along similar lines, scientists are studying which physical rules dictate how blood cells stick to one another to form clots.

Strong bonds in wet places

Mother Nature is giving chemists pointers in their quest to solve some of the toughest questions in adhesion science. Consider one: How can you develop an adhesive that makes strong bonds in wet places—a glue that works in damp environments, or even underwater?

Biochemist Herbert Waite of the University of California–Santa Barbara studies the complex processes that allow mussels to rapidly create super-strong adhesive plaques underwater. Mussel glue is renowned for its ability to bond the soft underbelly of the mussel to wet rock, wood, and the steel hulls of ships with equal gusto.

"At the molecular level they can adjust the stiffness of threads and plaques," Waite said. "It helps to have a high stiffness close to the stone." The key to mussel glue's stickiness, Waite discovered years ago, seems to be 3,4-dihydroxyphenylalanine (DOPA), an amino acid found abundantly in the mussel's bonding proteins.

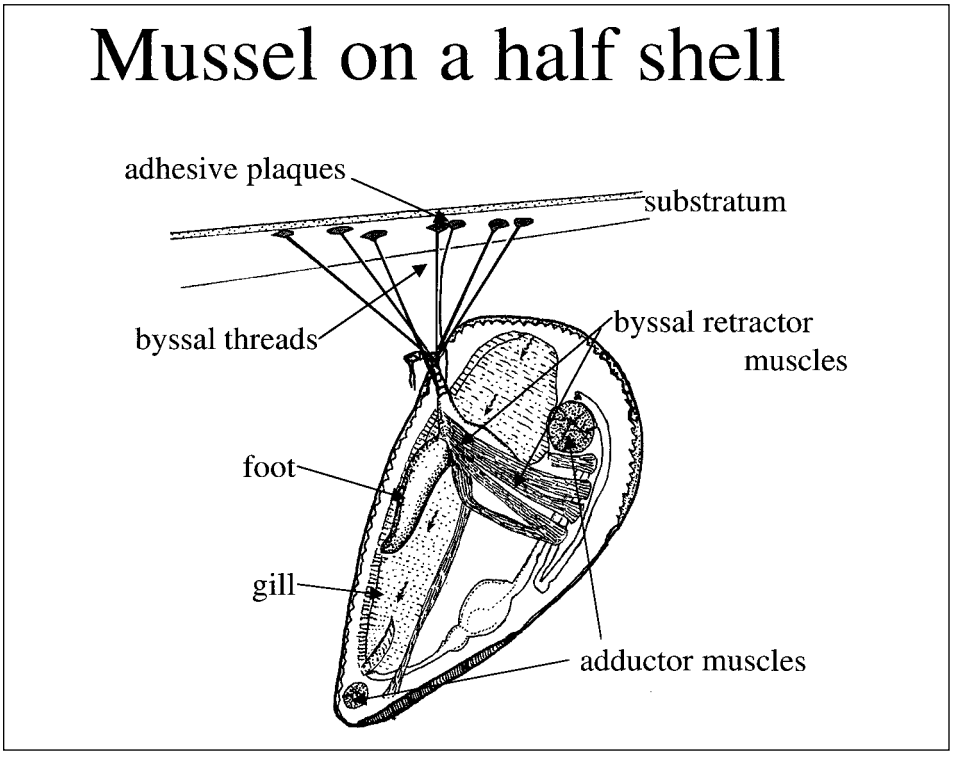
Research on how DOPA works is of great interest to chemical engineers trying to make glues and patches that could be used in one especially crucial moist place—the human body. Doctors already use cyanoacrylate adhesive gels to close certain skin wounds.

"Cyanoacrylate is probably the best at adhering to wet tissue, but most of the cyanoacrylates are brittle," said Northwestern biomedical engineer Philip Messersmith (ACS '93). Along with others in the field, Messersmith is racing to devise new DOPA-based underwater adhesives. He and collaborators also hope to use DOPA-rich proteins to create slippery surface treatments for ships—so-called "anti-foulers."

Currently, ship owners spend millions of dollars each year on chemical agents in a losing battle against barnacles.

Messersmith is developing a polymer that uses DOPA-mediated bonding on ships underwater while presenting a slippery, polyethylene glycol surface to which cells have difficulty attaching. "We're taking advantage of one of nature's best foulers to create an antifouler," said Messersmith.

Another natural blockbuster glue is the polymeric stickum that bonds together segments of the abalone's shell. Intermediate ionic bonds, sometimes known as "sacrificial bonds," are the secret to the glue's durability. These links break under stress, preserving the chain's backbone. "The force required to break a sacrificial bond is low, but in order to get to break the sacrificial bond you have to remove the entropy, which requires work," said Paul Hansma, a biophysicist at University of California–Santa Barbara. Hansma and others are developing adhesives that exploit the sacrificial bond strategy.



HERBERT WAITE

MUSSELS USE "byssus" threads up to six centimeters long to attach to rocks or other large objects in the intertidal zone. The threads have the greatest energy dissipation or hysteresis of any extracellular biomaterial, and they exhibit recoverable strain softening when put under tension. This recovery process is a form of self-healing.

In the gecko's footsteps

Adhesion science is also benefiting from another of Mother Nature's adhesion secrets—what makes the gecko such a whiz at climbing.

Kellar Autumn, of Lewis and Clark College (Portland, OR), led a team that measured the adhesive force of the setae, the microscopic hairs on the reptile's feet. They established that van der Waals forces—and not surface polarity, as previously hypothesized—contribute to the super-stickiness of geckos' feet. First they showed that the gecko setae were equally effective at sticking to polarizable semiconductors of both the hydrophobic (SiO_2) or hydrophilic (GaAs) variety. Then they made tiny seta tips—each seta has as many as 1,000 of the structures, termed "spatulae"—out of silicone rubber and polyester resin. Both synthetic versions of the spatulae stuck equally well. That suggested it was primarily the shape and size of the spatulae that made them effective, not their composition—further proving the van der Waals theory.

Now scientists are following in the gecko's footsteps. A group led by Ron Fearing, an electrical engineer at the University of California–Berkeley, fabricated impressively sticky spatulae, stubby "nano-bumps" that resemble the actual flyswatter-like spatulae that coat geckos' toes. The military already envisions a use for the spatulae, if they can be mass-produced: wall-climbing robots. With funding from the Defense Advanced Research Projects Agency (DARPA), a firm named "iRobot" has built gecko-like climbing robots that may soon use pressure sensitive adhesives and claws to climb up a variety of surfaces. One day they may scurry across ceilings on nanobump toes.

Smart adhesives

To Autumn, adhesion science is undergoing nothing less than an upheaval. "The revolution in adhesion is going to come in so-called smart adhesives," he said. "We think we've discovered the smartest adhesive of them all," he said.

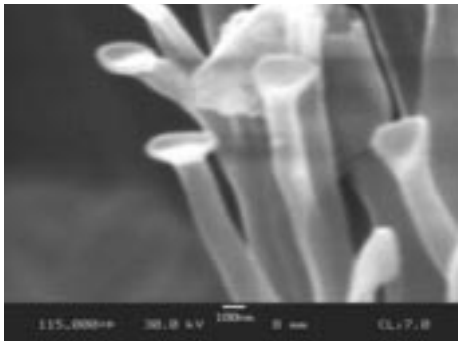
Other scientists have their own candidates for high-IQ adhesives.

A number of laboratories are developing surfaces that change their stickiness on command. Smith & Nephew plc, a British medical devices company, for example, is currently designing a pressure-sensitive adhesive bandage that can hold tightly to the skin. But when light is shined directly onto the adhesive, the polymer chains in the adhesive cross-link, decreasing the wettability of the adhesive on skin, allowing the bandage to peel off more easily.

Along the same lines, Virginia Tech chemist Tim Long (ACS '82) is investigating how to make a bandage with reversible adhesion by employing a light-induced ester cleavage reaction. The reaction would cut the chains, making the adhesive as a whole far less sticky, allowing the bandage to fall off. Long also is working on adhesive putty that could be used to close up veins or arteries. The military is seeking that kind of technology for battlefield treatment of hemorrhaging wounds. When light is directed on the material after it's in place, Long explained, the polymer chains in the adhesive could be shortened by hydrolysis, hardening the putty.

"The old perspective is to look at adhesion as 'glue,' " said Long. "We're interested in taking molecules and letting them be dynamic."

Eli Kintisch got stuck with this assignment while a freelance science writer in Washington, DC. His bonds to the nation's capital later loosened, and Eli now is writing science news for the St. Louis Post-Dispatch.



KELLAR AUTUMN

GECKO FEET are covered with "spatulae," tiny structures that use van der Waals forces to give the creature its amazing ability to stick to surfaces and climb.

KELLAR AUTUMN

CROSSWORD solution

TO WINTER 2004 *CHEMISTRY* PUZZLE

H	E	M	O	C	C	U	L	T	■	F	E	V	E	R
U	■	O	■	H	■	V	■	R	■	O	■	E	■	E
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G	L	A	B	E	L	L	A	■	V	E	C	T	O	R
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S	C	A	L	E	■	T	H	R	■	T	O	X	I	N
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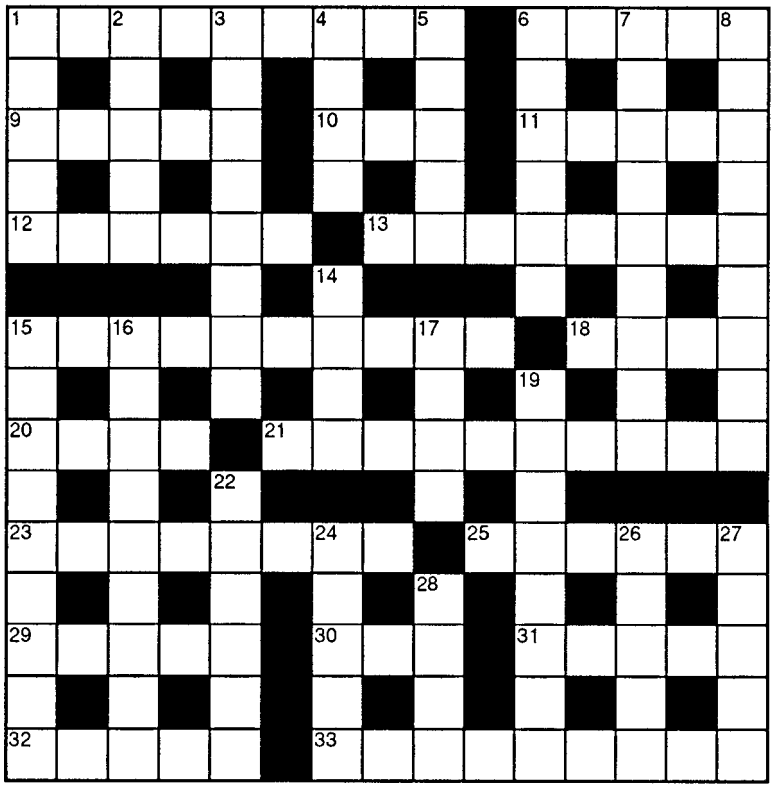
CROSSWORD BY ERIC ALBERT



ACROSS

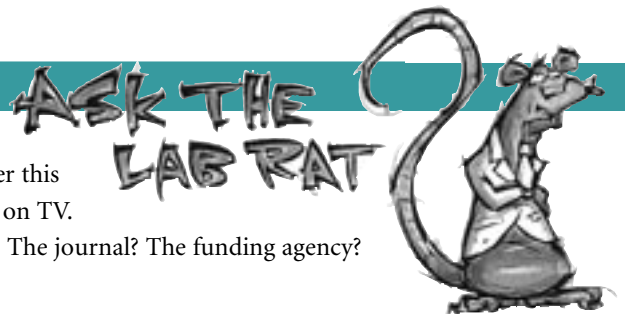
1 Pertaining to hidden blood
6 Infection response
9 Cursor controller
10 Prefix for quintillion
11 Tonsillitis pathogen
12 Type of acid used in making explosives and fertilizers
13 Thiamine-deficiency result
15 Secondary structure for a protein
18 Helper in polypeptide-chain building: abbr.
20 Neuron appendage
21 Structure appearing during cell division
23 Flat area of bone between the eyebrows
25 Pathogen transmitter
29 Thin, flat, horny plate
30 Polar amino acid: abbr.
31 Serum target
32 Pathogen
33 French cave known for skeletal remains

DOWN

1 Piece of "HTLV"
2 Prepare for microscope viewing
3 Kind of engineer
4 Eye layer
5 Minute quantity
6 It means "dug up," etymologically
7 Spine components
8 Enzyme involved in the viral-RNA copying process
14 Pool member
15 Painkiller's gift
16 Transmit to offspring
17 Greek letter
19 Beavers, rats, porcupines, et al.
22 Long terminal _____
24 Pertaining to cell destruction
26 Phylum, for one
27 Kidney product that helps produce angiotension
28 Conclusion beginning

Solution to this puzzle can be found on page 34.

Dear Lab Rat,



We're publishing results of a research project later this year, and want to get this in the newspapers and on TV. Who can help us get the news media's attention? The journal? The funding agency? Our university media relations offices?

—Publicity Conscious

Dear Publicity Conscious,

All of the above.

That headline in today's newspaper, those sound bites on the evening news, the cover stories in next week's national news magazines often result from a carefully coordinated effort among media relations people at a scientific journal, funding agency, and university. But it all starts with you—the scientists who have done the research. You've got to take the initiative or the public may never hear about that breakthrough discovery.

Banish any concerns about tooting your own horn. Calling attention to your research findings is not patting yourself on the back. It is a responsibility, especially if the research involved government funds. Listen to what Arthur B. Ellis (ACS '73), director of the National Science Foundation's chemistry division, said in a recent letter (www.nsf.gov/pubs/2003/nsf03016/nsf03016.html) to grantees.

"We regard the timely communication of your research advances to nonspecialist audiences—those in other technical fields, teachers, students, industry, government, and the public—as an important shared responsibility. Making your research accessible in this way enables us to explain why investment in chemistry is essential."

Public relations is not flummery or smoke-and-mirrors. It is, as PR guru Scott M. Cutlip said 50 years ago, "Good performance, publicly appreciated."

To get public appreciation of yours, follow Ellis' advice. If NSF funded the research, let them know if you're going to publish a report in a journal or make a presentation. Ellis invited grantees to contact him directly (aellis@nsf.gov), or to contact their program officer or the NSF department of legislative and public affairs (tellus@nsf.gov). If it involved another funding agency, contact your program officer or media relations people there. Be sure to inform your university media relations office, and follow whatever procedures they have established.

If you will be publishing in an ACS journal or presenting at an ACS meeting, contact the ACS News Service (newsroom@acs.org; 1-800-227-5558, ext. 4440), which helped pioneer the concept of publicizing scientific research results. Each year the ACS News Service helps to generate thousands of news articles and broadcasts about chemical research that reach a potential audience of many millions.

Spend time preparing a good, coherent pitch for the media relations people. If they decide the discovery is not newsworthy, everything may stop right there. Include a brief description of your discovery, when and where it will be published or presented, and why it is "newsworthy." That usually means new, important in a scientific or practical sense, unusual, or unexpected. The discovery itself, or the way in which it occurred, may fit that bill.

Give the media people plenty of lead time. It takes time to prepare a media announcement, or "release." And the content often has to be reviewed and approved by multiple parties. Some journals have embargo policies related to publicity on forthcoming articles. They restrict public announcements until publication date of the article. Don't worry about "leaks." You'll be telling professionals accustomed to complying with those policies.

If your discovery merits publicity, a news release will be prepared and made available to science journalists around the world, usually in advance of the publication date. It will include telephone and e-mail contact information for the head researchers or someone in the group designated to answer media questions.

Plan on being accessible to journalists for questions by e-mail or telephone before the release date. Many journalists write stories in advance and hold them for the official release date. Even though you may think the news release tells the full story, journalists will have questions. You may be surprised at their scientific sophistication.

Never leave a journalist dangling in the wind. Respond promptly to each request for a telephone interview or to e-mailed questions, or explain straight out why you won't be responding.

Then sit back and enjoy the public appreciation of your group's good performance.

—A.K.A. Muridae

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FOR MEMBERS ONLY

Exciting times for chemistry in drug discovery

ACS President Elsa Reichmanis (ACS '71) and Magid Abou-Gharbia (ACS '74), vice president of Chemical and Screening Sciences at Wyeth Research, cohosted a meeting of head researchers in chemistry and discovery from the pharmaceutical industry. This meeting, the first of its kind, took place on October 3 at Wyeth's new facility in Collegeville, PA. Gathering nearly 40 participants, the meeting included research leaders from more than a dozen large and smaller pharmaceutical and pharma services companies. Other participants from ACS technical divisions, academe, and ACS staff units that develop products and services for pharma professionals also participated. ACS convened the meeting so that drug company executives who lead chemical and discovery research could gather and discuss common issues. According to Dr. Reichmanis, the meeting also explored possible ways in which ACS can continue to meet the needs of chemists involved in drug discovery. Discussions covered chemistry's role in current drug discovery trends, the balance between biology and chemistry in developing drugs, and the training of new graduates entering the pharma workforce. Participants felt that the meeting took a valuable first step toward future efforts between ACS and industrial research leaders in drug discovery. ⬢

Chemjobs surveys job seekers

The results are in. According to a demographic and customer satisfaction survey, *Chemjobs*, the *Chemical & Engineering News* classifieds and careers website, is a hit with jobseekers. Of the 1,345 registered job seekers who responded to the e-mail survey, 53% visited the site once a week and 65% were actively looking for a job.

Job seekers gave *Chemjobs* high marks in comparison with other jobsites; 80% rated the site as excellent or good overall. Ninety percent of the respondents rated *Chemjobs* as easy to use for posting a resume, searching and applying for jobs, and setting up job alerts.

The majority of respondents were between the ages of 26 and 45, and half held doctorates. Industry employed 46% of the respondents and 29% worked in academe. The most sought-after jobs were in research.

Go to www.cen-chemjobs.org and start your search for a new job today! ⬢

Wyeth President of R&D Bob Ruffolo speaks with meeting cohosts ACS President Elsa Reichmanis (ACS '71) and Magid Abou-Gharbia (ACS '74), Wyeth vice president for chemical and screening sciences.

Four popular Career Services publications updated

If you are an ACS member planning to enter the job market, you will find four newly updated ACS Department of Career Services publications helpful in organizing an effective job search. All are available free of charge to members.

The four publications are: *Job-Search Strategies for Chemical Professionals*, *Resume Preparation—Tips for Chemical Professionals*, *Interviewing Skills for Chemical Professionals*, and *Employment Guide for Foreign-Born Chemical Professionals*.

In brief, *Job-Search Strategies* helps job seekers identify the market they want to access and how to mount a campaign. *Resume Preparation* is a guide that assists job candidates in making the best possible first impression on a potential employer. *Interviewing Skills* offers candidates tips about the interviewing process and how they can refine their skills. *Employment Guide* serves as a basic information resource regarding U.S. employment.

All four are among the most frequently requested publications in the ACS catalogue. For more information, call the ACS Office of Society Services at 1-800-227-5558 or e-mail help@ACS.org. ⬢

Kick Off 2004! ACS Member-Get-A-Member

Share the ACS knowledge you've discovered with your colleagues, staff members, fellow professors, and friends. They will experience the rewards of membership and thank *you* for it! And for your efforts, we'll thank you by entering your name (one time for each qualified recruit) into our 2005 National Meeting Sweepstakes. All you have to do is take your pick between sunny San Diego and historic Washington, DC, if you are the Sweepstakes Grand Prize Winner!

Entering is a SNAP! (1) Draw up your list of candidates—colleagues, fellow professors, and friends. (2) Go to chemistry.org/membership and either download the PDF version or fill out the form online. (3) Sign the form yourself.

Your name will be entered in the sweepstakes drawing each and every time one of your candidates is accepted for membership. So, the more members you recruit, the greater your chances of winning.

With ACS…everyone is a winner! Even if you don't win the grand prize, you're still a winner. You will become a member of the President's Club and your name will appear in *Chemical & Engineering News* and *Chemistry*. Most important, by helping attract more members like you to the Society, you help ensure that the organization you care about continues to be strong and growing. For a listing of the 2003 members of the President's Club, go to chemistry.org/membership/presidentsclub.html ⬢

Spring 2004 National Meeting Presidential Events

Scheduled for Sunday afternoon, the *Presidential Colloquium on Nanoscience and Technology* will feature experts who will review the basics of nano-research in a variety of fields and offer insights into possible future developments. Speakers who had accepted at press time include Jillian Buriak (ACS '94), University of Alberta; Donald Eigler, IBM Almaden; Arthur Ellis (ACS '73), National Science Foundation; James Heath, California Institute of Technology; George Lisensky (ACS '79), Beloit College; and Mark Ratner (ACS '73), Northwestern University. At the reception that will follow, guests can see artistic renditions of nanomaterials.

Related divisional programming includes Nanoscale chemical analysis of biological systems (ANYL), Biochemical aspects of nanoscience (ANYL), Informatics challenges in nanotechnology (CINF), Surface chemistry of inorganic materials (INOR), Nanoscience in inorganic chemistry (INOR), Optical microscopy beyond the diffraction limit (PHYS), and Nanocrystals and nanotubes (PHYS). See the Anaheim program (Feb. 2 and Mar. 8 issues of *C&EN*) for more details.

Tri-Presidential Symposium: the NRC Report, "Beyond the Molecular Frontier," cosponsored by the ACS President, President-Elect, and Immediate Past President. Scheduled for Sunday evening, this symposium will feature speakers who participated in developing the NRC report, which identifies opportunities and challenges for chemical practitioners in the 21st century. Speakers who had accepted at press time include Ronald Breslow (ACS '51), Columbia University; Uma Chowdhry, Dupont Co.; Michael Sailor (ACS '82), University of California–San Diego; Ellen Stechel (ACS '94), Ford Motor Co.; and Matt Tirrell (ACS '74), University of California–Santa Barbara. The report can be read for free on the web at www.nap.edu/catalog/10633.html. This website also includes an excellent short summary of the report that can be downloaded as a pdf file.

Related divisional programming includes Feedstocks for the future: Renewables for the production of chemicals and materials (CELL); Inspired by nature: From biosynthesis to advanced renewable materials (CELL); Advances in pharmacophores and 3-D searching (CINF); and The bigger picture: Linking bioinformatics to cheminformatics (CINF). ⬢

Sponsored by ACS President Charles P. Casey (ACS '62), presidential events at the 227th National Meeting in Anaheim, CA, March 28–April 1, 2004 are open to all meeting attendees.

Great Chemistry at Regional Meetings!

Come find great chemistry at the spring 2004 regional meetings! Regional meetings offer chemists and chemists-to-be an exciting opportunity to share their work and to network with colleagues in a convenient and economical setting.

The Indiana Local Section will host the Central Region Meeting (CRM) in Indianapolis, June 2–5, at the conference center of the Indiana University–Purdue University, Indiana (IUPUI). The Northwest Meeting (NORM), hosted by the Salt Lake Local Section, takes place at the University of Utah, Logan, from June 6–9.

Online abstracts open for both meetings in mid-January and will close March 31.

Beginning in 2003, all regional meetings abstracts became part of the CAS online programs. Your work will be accessible worldwide! For more details about all of the 2004 regional meetings, visit the Regional Meetings website at www.acs.org/meetings/regional; call us at 800-ACS-5558, ext. 6129; or e-mail us at regmtgs@acs.org. ⬢

Why IQ is Not Enough: Secrets to Realizing your Full Career Potential

The Women Chemists Committee will sponsor a workshop called *Why IQ is Not Enough: Secrets to Realizing your Full Career Potential* during the ACS spring national meeting in Anaheim, CA. The course will take place on Monday, March 29, 2004 from 9:00 a.m. to 4:00 p.m. and includes lunch.

This workshop introduces participants to the concept of "emotional intelligence" and looks at the crucial link between emotional intelligence skills and career success. The course will explore each area of emotional intelligence, allowing participants to gather ideas and formulate strategies for taking specific action to increase their emotional intelligence. The material provides practical advice for those who get "triggered" easily and for those who feel like they have to "walk on eggshells" around certain people (or feel that others have to walk on eggshells around them). It teaches the biochemistry behind getting "emotionally hijacked" and specific techniques that will help participants "cool down" their own or others' emotions. By the end of the workshop, each participant will have both a personal development plan for honing EQ skills in order to maximize career potential and an emotionally intelligent strategy for dealing with others who may get emotionally hijacked.

To register, print the form from the WCC website at http://membership.acs.org/w/wcc/. The workshop costs $199 per participant; please send the check and registration form to Dr. Amber Hinkle (ACS '92), the WCC Subcommittee chair, at 535 County Road 4015, Dayton, TX 77535. For more information, email amber.hinkle@bayerpolymers.com. The deadline for registration is February 15, 2004. ⬢

Former ACS President Dr. Alan C. Nixon will be remembered at the ACS National Meeting in Anaheim for his role in establishing Project SEED.

Reception planned in memory of Dr. Alan C. Nixon

The Division of Professional Relations (PROF) will host a reception in memory of Dr. Alan C. Nixon on Monday, March 29, 2004 at the ACS national meeting in Anaheim, California. Alan Nixon spent 33 years in the labs of Shell Development in Emeryville, but his accomplishments were not confined to the world of plastics, paper chemicals, and jet airplane fuels. He is also remembered for his role in establishing Project SEED, now responsible for opening the door to science and chemistry for more than 7,000 disadvantaged students over the past 35 years. Nixon, an active member of the ACS California Section and two-time section president, served in many offices, including that of ACS president in 1973. The Alan Nixon Memorial Fund for Project SEED will be dedicated at this gathering.

For more information about how to make a gift to Project SEED, contact the ACS Development Office at 202-872-4094. ⬢

Inside ACS

FOR OUR FUTURE MEMBERS

Undergraduate transitions: Enhancing student success

Resources and strategies that facilitate student transfer and foster student retention will be highlighted at the 2004 Biennial Conference on Chemical Education (BCCE), July 18–22 at Iowa State University in Ames, IA.

Undergraduate Student Transfer: Addressing the Challenges, will be sponsored by the Society Committee on Education (SOCED), Committee on Minority Affairs (CMA), and Committee on Technician Affairs (CTA). It will focus on such topics as student needs for advising and curriculum along various academic pathways to chemistry careers, resources and programs currently in place, ways to involve chemistry faculty from both two- and four-year institutions, and improving communication and strengthening academic programs.

AACC

George Boggs, President/CEO of the American Association of Community Colleges, will be the keynote speaker at the 2004 Biennial Conference on Chemical Education.

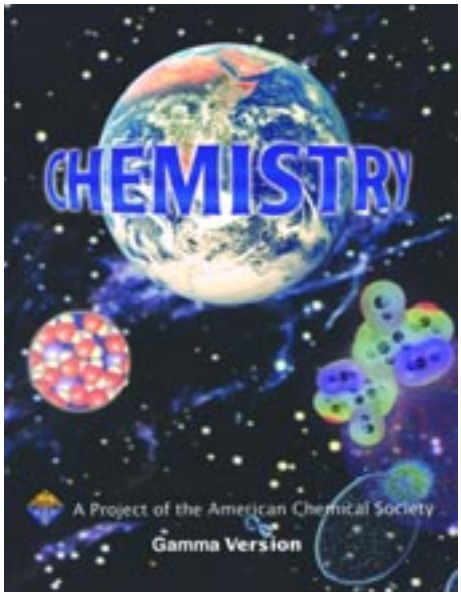
The program will include a keynote presentation by George Boggs, president and CEO of the American Association of Community Colleges, a poster session, and a symposium with panel discussions.

For more information, please contact Jodi Wesemann at j_wesemann@acs.org or 1-800-227-5558, x4587. Abstracts should be submitted at the BCCE web site (www.chem.iastate.edu/bcce) by January 26, 2004. ⬢

2003 ACS Directory of Graduate Research is now available!

The *2003 ACS Directory of Graduate Research* is the premier source of information on faculty and their research programs in chemistry, chemical engineering, biochemistry, and related sciences in the U.S. and Canada. It lists faculty member biographical information, areas of specialization, titles of all papers published within the last two years, telephone numbers, and FAX numbers. It also contains listings for 669 academic programs, 10,522 faculty members, and 72,450 publication citations.

The *Directory* is also available as *DGRweb*,



an easy-to-use, searchable database that contains all the information found in the book. *DGRweb* provides direct links to faculty and departments via e-mail and website addresses. *DGRweb* is a great resource that allows you to find out quickly who is doing what type of research in chemistry and related disciplines. If you would like more information about how to order a copy of the *Directory* or *DGRweb*, call the ACS Office of Society Services at (800) 227-5558. ⬢

ACS 2004 *Chemistry* Workshops

The new textbook, *Chemistry* (a project of the American Chemical Society), is designed to support and reinforce an activity-based, student-centered approach to teaching general chemistry. *Chemistry* presents traditional chemistry concepts in a nontraditional order. Its pedagogy builds on active learning and group interactions. As often as possible, *Chemistry's* concepts and principles are developed by analyzing data obtained in classroom activities.

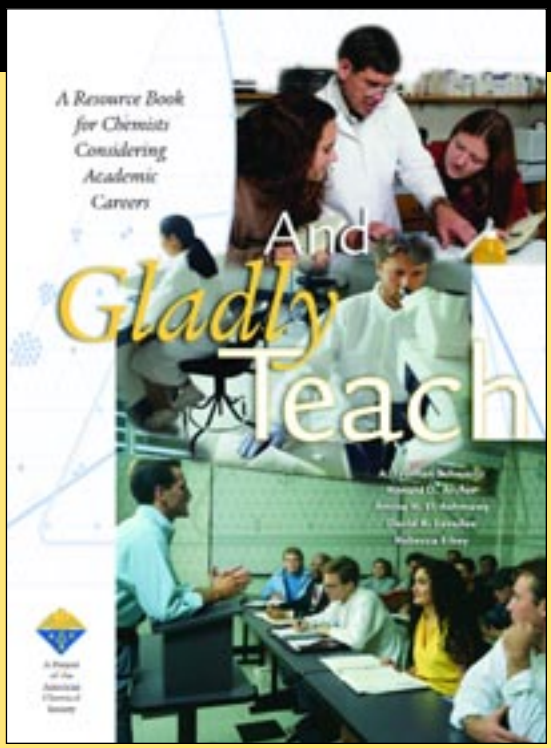
ACS is presenting workshops to help prospective users develop a better understanding of this new textbook's content and pedagogy. These sessions will also show how *Chemistry* has worked in classrooms. A half-day workshop will be held on March 27 before the ACS Meeting in Anaheim, CA. A one-and-a-half-day workshop July 16–17 will precede the Biennial Conference on Chemical Education in Ames, IA. For more information about applying for these workshops or obtaining a draft copy of the textbook, contact Marta Gmurczyk (m_gmurczyk@acs.org). ⬢

And Gladly Teach: A Resource Book for Chemists Considering Academic Careers

The ACS Office of Graduate Education and the Department of Career Services have recently published a book entitled *And Gladly Teach: A Resource Book for Chemists Considering Academic Careers.*

The specific topics the book addresses include the nature of an academic position in various types of institutions; choosing between a postdoctoral position and a temporary teaching job; and preparing a curriculum vitae, research proposal, and statement of teaching philosophy. In addition, the book discusses campus visits, weighing competing job offers, and balancing time demands while working toward tenure. The book includes an extensive bibliography of printed and electronic sources.

Copies can be obtained from the ACS Office of Graduate Education at graded@acs.org. ⬢



Inside ACS

College Chemistry Consultants Service upgrades its expertise

The College Chemistry Consultants Service held a workshop for its consultants on October 4 at ACS headquarters in Washington, DC. Attendees worked with the most recent set of ACS guidelines, which were published in the spring of 2003, to prepare for consulting visits to schools that wish to improve their chemistry departments. Teams of consultants worked on fictional case studies of schools preparing to apply for ACS approval of their chemistry programs. The workshop participants learned how to examine such key components of chemistry departments as teaching loads, departmental budgets, and undergraduate research.

To obtain more information or arrange a consultant visit, call 1-800-227-5558, ext. 6124, or visit www.chemistry.org/portal/a/c/s/1/acsdisplay.html?DOC=education%5Cinstitutional%5Cc3s.html. ⬢

ACS mascot: A source of pride and fun

An ACS member recently shared the following with us: "While out driving, I saw a license plate that said 'I ❤ KMSTRI.' I was delighted that someone had shown the commitment and tenacity to display his [or her] love of our science!"

"It made me realize how important symbols can be. They express the things we care most about, and they do it in a lot of different ways."

This member couldn't have expressed our philosophy here at the American Chemical Society better. It is our mission to enhance the visibility, prestige, and importance of chemical science and its various practices in any way we can.

With this in mind, the ACS membership division came up with a fanciful, yet logical, mascot to represent our Society—the Mole.

You may already have seen images or 3-D (stuffed) recreations of this critter named Professor Molennium.

Because of the immense popularity, Professor Molennium is featured on many of our ACS products—shirts, mugs, note cards—and you can view them all at our online store, chemistry.org/store.

So, the next time someone asks you, "What's the Mole got to do with it?" ("it" being chemistry), you can answer without hesitation: "Just about everything!" ⬢

Heroes of Chemistry 2003

On Sunday, September 7, at the 226th ACS meeting in New York, 17 scientists were honored as the 2003 Heroes of Chemistry. Nearly 700 guests attended a gala that jointly celebrated this year's Heroes and the 80th anniversary of *Chemical & Engineering News*. Special guests, including Nobel laureates, joined executives from more than 40 corporations and ACS governance and staff.

The Heroes of Chemistry awards program annually highlights the contributions of industrial chemical scientists to their companies, to the global marketplace, and to humanity. Industrial scientists are rarely recognized for the important contributions that they make to society. *Heroes of Chemistry* is unique in that it specifically recognizes industrial innovation.

This year, the ACS recognized scientists whose work has improved children's health and wellness through the successful research and development of a commercial product based on chemistry. The four teams honored were from Abbott Laboratories, Merck Research Laboratories, Pfizer Inc, and Wyeth Pharmaceuticals. The evening's keynote speaker, Benjamin S. Carson, M.D., director of the Division of Pediatric Neurosurgery at Johns Hopkins University, placed great emphasis on the role of scientists as heroes to young people.

For more information, please go to www.chemistry.org/industry/heroes. ⬢

One of four teams honored as Heroes of Chemistry 2003. Drs. Young (ACS '79), Labelle (ACS '82), and Zamboni (ACS '87) of Merck Research Laboratories were honored for their discovery of Singulair.

COMMUNITY RESOURCES

WCC Overcoming Challenges Award for women undergraduates

The Overcoming Challenges Award acknowledges the efforts of women undergraduates who have overcome economic, personal, and/or academic hardships in pursuit of an education in the chemical sciences. The award consists of a plaque, a $250 honorarium, and $1,000 for travel expenses to the ACS Fall National Meeting, where the award is presented.

Award candidates must be women matriculating as an undergraduate chemical science major/minor in a two-year program or at a four-year school not granting a doctoral degree in chemical-related disciplines. Nominations are due May 1, 2004, and should be sent to: Women Chemists Committee; American Chemical Society; 1155 16th Street, NW; Washington, DC 20036. Visit http://membership.acs.org/W/WCC for more information. ⬢

Passer Education Funds Available

The Dorothy and Moses Passer Education Fund provides support for teachers in programs at two- and four-year colleges or universities that do not have any advanced degree programs in the chemical sciences. An appointed committee reviews the applications three times each year. Deadlines for the review cycles are January 1, April 1, and September 1. Applicants should send a request for funds by e-mail (preferred) to djones@erols.com, by fax, or by regular mail to Donald E. Jones, 3726 Connecticut Ave., N.W., Apt. 108, Washington, DC 20008; 202-364-2740. There is no specific application form. Applicants are encouraged to submit their requests as early as possible, preferably by e-mail. For details about the fund or to request other information, send an e-mail to djones@erols.com. ⬢

Mark your calendar!

ACS National Meetings

227th, Spring, March 28–April 1, 2004
Anaheim, CA

228th, Fall, August 22–26, 2004
Philadelphia, PA

2004 ACS Regional Meetings

Middle Atlantic Regional Meeting
No meeting in 2004

36th Central Regional Meeting
June 2–5, Indiana–Purdue Univ.
Indianapolis, IN

59th Northwest/18th Rocky Mountain Regional Meeting
June 6–9, Utah State Univ.
Logan, UT

60th Southwest Regional Meeting
Sept. 29–Oct. 2
Fort Worth, TX

36th Great Lakes Regional Meeting
Oct. 17–20, Hotel Pere Marquette
Peoria, IL

39th Midwest Regional Meeting
Oct. 19–22, Kansas State Univ.
Manhattan, KS

40th Western Regional Meeting
Oct. 27–30, Doubletree Hotel
Sacramento, CA

33rd Northeast Regional Meeting
Oct. 31–Nov. 3, Hyatt Regency
Rochester, NY

56th Southeast Regional Meeting
Nov. 10–13
Raleigh/Durham, NC

2004 ProSpectives Conferences

Organic Thin Film Electronics
January 25–28
Miami, FL

Polymorphism in Crystals
February 8–11
Tampa, FL

Process Chemistry in Pharm
February 29–March 3
Tampa, FL

Pharm Authentication/ Forensic Analysis
April 25–27
Tampa, FL

Chemicals and Biosensing
May 16–19
Santa Fe, NM

For more information, call 800–227–5558, toll-free, or e-mail help@acs.org.

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